Commission for Basic Systems

Extraordinary session

Asunción
8–12 September 2014

Abridged final report with resolutions and recommendations

World Meteorological Organization
Weather • Climate • Water

WMO-No. 1140

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GENERAL SUMMARY OF THE WORK OF THE SESSION

1. OPENING OF THE SESSION (agenda item 1)

1.1 Formal opening of the session (agenda item 1.1)

1.1.1 At the kind invitation of the Government of the Republic of Paraguay, the 2014 Extraordinary Session of the Commission for Basic Systems (CBS Ext.(2014)) was held in Asunción, Paraguay from 8 to 12 September 2014. The session was declared open by Mr Fredrick Branski, president of the Commission, at 9:30 am on Monday, 8 September at the Conmebol Conference Centre, Asunción, Paraguay.

1.1.2 Mr Branski, president of the CBS, welcomed the distinguished guests and delegates to the 2014 Extraordinary Session of the Commission for Basic Systems. He noted that this was the first session of CBS in South America and the first session of any Technical Commission held adjoining a Regional Association session. He noted that the session was particularly important because of the large number of changes to regulatory material, including for WIS, WIGOS, DPFS and support for ICAO, that would form recommendations to the seventeenth Congress.

1.1.3 Mr Branski thanked the Government of the Republic of Paraguay for agreeing to host the Session and for making such excellent facilities available.

1.1.4 Mr Branski noted that the agenda focussed on decisions relating to the implementation of WIGOS, but that it also included urgent and critical updates to the Technical Regulations to support rapid progress with WIGOS, WIS and other WMO Priority areas and Cross-Cutting Programmes. He encouraged the delegates to work as efficiently as possible given the short time available for dealing with the complex issues.

1.1.5 The Representative of the Secretary-General, Dr Wenjian Zhang, also thanked the Government of the Republic of Paraguay for hosting the session. He went on to note the importance of the session of the Commission for making decisions on the implementation of WIGOS, WIS, and other WMO priority activities. He also noted that Regulations require that technical decisions are recommended by Technical Commissions before they are submitted to Congress, and the Extraordinary Session was essential to achieve this. He also stressed the opportunity of the session to emphasize the essential contributions of CBS to achieving the objectives of the new strategic plan and strategic priorities that would be considered by the seventeenth Congress.

1.1.6 Dr Luis Manuel Aguirre, President of the National Civil Aeronautics Directorate, expressed his thanks to WMO for accepting the invitation to hold the CBS and RA III sessions in Paraguay, and recalled that it had been 25 years since the last WMO session was hosted by Paraguay. He observed that the sciences of meteorology and hydrology had advanced during that time, and that Paraguay was now in a position to take preventative rather than reactive actions in response to weather related events. He noted that reacting to the impacts of an event was seven times more expensive than the actions needed to mitigate the impacts before they arose.

1.1.7 Ambassador Mr Federico González, Vice-Minister for external relations, expressed a warm welcome to delegates from around the world. Twenty-five years ago, when the last WMO session was held in Paraguay, there had been only one television channel, and he remembered looking forward to the end of the daily news programme when the weather forecast was presented. This early lesson on the importance of weather information had been reinforced by his time as Ambassador of Paraguay to the United Nations in Geneva and his interactions with WMO while there. The thunderstorms preceding the meeting, added to the pre-existing flooding, provided a reminder of the importance of the work of the Commission.

1.1.8 A complete list of participants is given in the appendix to the present report.

1.2 Adoption of the agenda (agenda item 1.2)

The agenda for the session was unanimously adopted, as contained in document CBS-Ext.(2014)/Doc 1.2.

1.3 Consideration of the report on credentials (agenda item 1.3)

In accordance with General Regulations 21 to 24, the Commission noted and approved the report of the representative of the Secretary-General as the report on credentials.

1.4 Establishment of committees (agenda item 1.4)

1.4.1 In accordance with Regulations 23 to 32, the session decided to establish a Coordination Committee. The Coordination Committee comprised the president of the Commission, the vice-president of the Commission, the Co-Chairpersons of the OPAGs and the Secretariat staff at the meeting who were responsible for managing the documents. The Commission agreed that the work of the session would be carried out in plenary. The president would chair agenda items 1, 2.1, 2.3, 2.6, 3.1, 3.2, 3.4, 3.5, 4.1, 4.2, 4.3, 4.5, 5 and 6; the vice-president would chair agenda items 2.2, 2.4, 2.5, 3.1, 3.3 and 4.4.

1.4.2 The Commission decided to set up the following Committees for the duration of the session:

(a) Coordination Committee chaired by the President;

(b) Relationship with Humanitarian Agencies Committee chaired by Mr Michel Jean, Canada, with members from Brazil, France, Ireland, Japan, the Russian Federation, the United Kingdom of Great Britain and Northern Ireland and the United States of America;

(c) WIS Centres Committee chaired by Mr Dieter Schröder, Germany, with members from Brazil, Canada, China, Croatia, EUMETSAT, France, Italy, Japan and the Russian Federation;

(d) Review of WIGOS Regulatory Materials Committee chaired by Mr Jochen Dibbern, Germany with members from Australia, Brazil, Canada, China, Croatia, India, Japan, the Russian Federation, the United Kingdom and the United States.

1.5 Other organizational issues (agenda item 1.5)

1.5.1 The Commission agreed on the working hours of the session. It agreed that minutes of the meeting were not required in view of the technical nature of the discussions. In accordance with Regulation 3, the Commission agreed to suspend Regulation 110 for the duration of the whole session.

Non-controversial documents

1.5.2 The Commission recognized that some of the decisions it had to make were determined solely by administrative procedures. The Commission agreed that errors in these documents could be corrected through editorial action and would not normally need to be debated in session.

1.5.3 The Commission also recognized that some of its decisions were of a highly technical nature and had been reviewed carefully by OPAG experts in the subject area. Such decisions would be unlikely to benefit from further debate by the Commission concerning the technical details. The Commission further recognized that the "fast track" and "approval between sessions" procedures for changes to the Technical Regulations had only been approved for the Table Driven Code Forms and for WMO Core Profile of the ISO 19115 Metadata Standard, but that for other topics the Commission had to approve changes with similar impact during a session.

1.5.4 The Commission noted the decision of EC-65 in paragraph 4.8.3.1 of the general summary of EC-65 to introduce non-controversial documents, and agreed with the recommendation of the CBS Management Group to use the same procedure at CBS Ext.(2014) and at future sessions.

1.6 President's report on key issues and developments (agenda item 1.6)

President's report

1.6.1 The Commission noted with appreciation the report by Mr F. Branski, president of the Commission for Basic Systems (CBS). Noting the significance of CBS activities for all WMO Programmes and priority areas, including the leading role assigned to CBS for many activities, the Commission recognized the substantial work carried out since the fifteenth session of the Commission.

Public Weather Services

1.6.2 The Public Weather Services (PWS) programme had coordinated efforts that culminated in the production and publication of "The WMO Strategy for Service Delivery and its Implementation Plan". The Strategy is WMO-wide and should be implemented by all WMO Programmes whose roles include service delivery as well as by WMO Regional Associations (RAs) and Technical Commissions (TCs). The Strategy was designed to assist National Meteorological and Hydrological Services (NMHSs) deliver high-quality services to user communities and improve their skills in communicating social and economic benefits to decision-makers.

1.6.3 There had been increasing demand on NMHSs by the public and the disaster community for information on the risk associated with hydometeorological hazards, likely effects on human beings and their livelihoods related to their vulnerability and exposure. In view of these demands, EC-65 (Geneva, 15–23 May 2013) recommended that NMHSs move towards impact-based forecasting and risk-based warning in the provision of public warning services in support of social resilience through behaviour modification in society. The PWS programme was leading in an effort to assist NMHSs transform their weather warning services accordingly. During the session the Commission would consider the future direction for addressing this issue, the "WMO guidelines on developing multi-hazard impact-based forecast and warning services" and support for the implementation of pilot projects and training in this area.

1.6.4 The public is increasingly using mobile devices such as smart phones to access weather information. As a result, many NMHSs were facing increased and steep competition from private service providers who provide weather forecast services through mobile devices using weather applications (weather apps). This situation was reducing the visibility and relevance of NMHSs especially in developing countries. There was therefore a need to assist NMHSs develop or acquire weather apps as a powerful channel of communicating forecasts and warnings. There was also a need to assist NMHSs develop capacities and skills to provide services through social media.

1.6.5 The Sixteenth World Meteorological Congress (Cg-XVI) (Geneva, May-June 2011) had recommended that all technical commissions define competency requirements for their respective core job-tasks. In this regard, the PWS programme had worked closely with the EC Panel on Education and Training to develop the Competency Framework for PWS Forecaster and Advisers. During the session, the Commission would consider a draft recommendation to endorse the Competency Framework as a WMO recommended Practice and for this to be included in WMO *Technical Regulations* (WMO-No. 49).

Disaster Risk Reduction

1.6.6 The CBS Task Team on the Provision of Operational Meteorological Assistance to Humanitarian Agencies was established by CBS-15 under the joint leadership/responsibility of the Open Programme Area Groups (OPAGs) on DPFS and PWS, and in liaison with other relevant

technical commissions and programmes. Under its Terms of Reference (TORs), this Task Team had to work on several areas which broadly included: the requirements for products and services by Humanitarian Agencies, the development of "Global and Regional Arrangements", and dissemination aspects.

1.6.7 The Commission would consider the development of an integrated holistic approach (as an authoritative framework) to support humanitarian agencies, noting the request by EC-66 that CBS review the governance procedures relating to the provision and availability of information on meteorological, hydrological and other environmental hazards, with a view to developing appropriate guidance for consideration by Cg-17 (2015). In this connection, a roadmap developed at a meeting of the Task Team in July 2014 would be considered by the Commission.

1.6.8 The term of the Hyogo Framework for Action (HFA) 2005–2015 would come to an end and the Third United Nations World Conference on Disaster Risk Reduction (WCDRR-III), in March 2015 in Sendai, Japan, was expected to adopt the post-2015 Framework for Disaster Risk Reduction. The session would consider and discuss the contributions of CBS and the inputs from Members to the Conference as well as to the preparatory consultations beforehand.

Data-Processing and Forecasting Service

1.6.9 Since the establishment of the new Open Programme Area Group (OPAG) structure, significant progress had been made by the Implementation Coordination Team on Data-Processing and Forecasting System (ICT-DPFS), in particular, the development of action plans for the next two, six and ten years to position the Global Data-Processing and Forecast System (GDPFS) for the future. The Commission would discuss the plan during the session. Also collaboration with the Commission for Climatology (CCl) through the joint CBS/CCl Expert Team on Operational Prediction on Sub-seasonal to Longer-time Scales (ET-OPSLS) and the CCl/CBS Expert Team on Regional Climate Centres (ET-RCCs) had paved the way for improved long range forecasting and high quality inputs to Regional Climate Centres and Regional Climate Outlook Fora.

1.6.10 Work continued in the five Severe Weather Forecasting Demonstration Project (SWFDP) regions involving 43 countries (Southern Africa – 16 countries; Eastern Africa – seven countries; Southeast Asia – five countries; South-Pacific Islands – nine countries; Bay of Bengal – seven countries). A number of training sessions were conducted and Regional Sub-project Management Team (RSMT) meetings were held. In order to facilitate coordination of the required work, the Secretariat had provided a full-time coordinator from January 2014.

1.6.11 Integration of the Flash Flood Forecast Guidance System (FFGS) with the SWFDP in South Africa had proven the concept of an integrated system. Joint training of meteorologists and hydrologists opened the door for close collaboration between these two operational disciplines for efficient service delivery. The significant contribution of USAID in facilitating the implementation of FFGS was acknowledged. The Secretariat would continue to favour the integration of these two systems in new SWFDP regions.

1.6.12 The SWFDP successes created demands for implementation in other areas, for example in Western Africa. These demands, combined with added pressure on Global Production Centres and Regional Specialized Meteorological Centres for the application of operational cascading process, put these centres at risk of not being able to meet the needs of NMHSs. In order to address this issue, the president of the Commission was tasked by the Presidents of Technical Commissions at their 2013 Meeting to develop a concept paper describing a proposal for a Programme or a mechanism to Strengthen Operational Centres (PSOC), building upon lessons learnt through the SWFDP. During the session, the Commission would review the proposal and consider the related recommendation.

1.6.13 Significant progress had been made in the revision of WMO-No. 485 *Manual on the Global Data-processing and Forecasting System: Volume I – Global Aspects*, but drafting had not

been completed. During the session the Commission would consider options for formal approval of the revised Manual.

Information Systems and Services

1.6.14 Significant progress had been made with the implementation of the WMO Information System (WIS), with all but one of the planned GISCs having been implemented. The emphasis had now turned to ensuring that all Members were able to take advantage of the opportunities offered by the WIS. Four regional associations already had plans for the implementation of the WIS by their Members, and Regional Association I was expected to endorse the plan for Africa at its session to be held in October 2014. Regional Association IV had yet to prepare a formal WIS implementation plan.

1.6.15 WIS centres have to demonstrate that they meet the requirements of WMO-No. 1060 *Manual on the WMO Information System* before they are endorsed. So that the continued effectiveness of the WIS is maintained, during the session the Commission would consider introducing regular reviews of the effectiveness of WIS centres, together with monitoring practices for the WIS to support continuous improvement. The effectiveness of WIS centres depends on the skills of staff at those centres and their ability to apply those skills. The Commission would also consider the competences that WIS centres need to draw on, and the training and learning needed to support development of those competences.

1.6.16 International civil aviation was a key user of the services of Members, and the International Civil Aviation Authority (ICAO) was expected to introduce a requirement for meteorological information to be made available in extensible markup language (XML) from 2016. This was just one of many application areas where users would in the future expect to be able to make direct use in their decision-making tools of information provided by Members. The CBS expert team that had developed the XML to support ICAO had done so in a way that it could be extended to meet the needs of other areas.

WMO Integrated Global Observing System (WIGOS)

1.6.17 WIGOS implementation had continued to progress well and that this was due in large part to the excellent co-leadership of Dr Susan Barrell, vice-president of the Commission, and Dr Bertrand Calpini, president of the Commission for Instruments and Methods of Observation (CIMO).

1.6.18 The WIGOS Framework Implementation Plan had been updated since CBS-15 and was approved by EC-66, with significant input provided by CBS experts. The WIGOS Core Semantic Metadata standard had been developed by ICG-WIGOS TT-WMD, with contributions on the needs for GOS-related metadata provided by the Commission's experts. WIGOS-related WMO Technical Regulations and a draft WIGOS Manual had been drafted with leadership from CBS experts.

1.6.19 The Inter-Programme Expert Team on WIGOS Framework Implementation (IPET-WIFI) Task Team on Regulatory Material (TT-RM) had produced a draft update to WMO-No. 544 *Manual on the Global Observing System: Volume I – Global aspects*, to make it consistent with the newly drafted Manual on WIGOS, and to eliminate duplication. The session would consider the draft update later in the session during agenda item 2.4. IPET-WIFI experts had also made progress on the development of regional and national scale strategies for collaboration with partner and external organizations, and feedback had been provided by IPET-WIFI to the WIGOS Project Office on the WIGOS capacity development and outreach strategies.

1.6.20 All six WMO Regions had developed their Regional WIGOS Implementation Plans (R-WIPs), facilitated through Regional WIGOS Workshops with substantial involvement from CBS experts. Four of the six R-WIPs had already been approved by their respective regional association session, while the R-WIPs for the two remaining Regions (I and III) were expected to be approved by those sessions later in the year.

1.6.21 The ICG-WIGOS Task Team on Regulatory Material (TT-WRM) had successfully completed the initial drafts of WMO *Technical Regulations* (WMO-No. 49), Vol. I, Part I – WIGOS, and the Manual on WIGOS. The preparation of these documents, which had involved very significant contributions by CBS experts, marked a very significant milestone for WIGOS. Both documents had been reviewed by all technical commissions and were in preparation for submission to all WMO Members.

1.6.22 The ICG-WIGOS Task Team on Metadata (TT-WMD) had successfully developed the initial WIGOS Metadata Standard, describing the required metadata once this element of WIGOS is fully implemented. TT-WMD further developed a phased approach for this implementation and provided a list of initial WIGOS Metadata and a description of the phased approach that was included in the draft Manual on WIGOS.

1.6.23 Following guidance from ICG-WIGOS, the Task Team on Quality Management (TT-WQM) had taken the initial steps toward a Quality Monitoring initiative within WIGOS. The initial focus area had been on modernizing the NWP-based monitoring of observational data quality for the Global Observing System. The work would be undertaken in close collaboration with OPAG-IOS and its Expert Teams, in particular IPET-OSDE and ET-SBO who would retain leading roles in the development of specific systems and procedures for this component of WIGOS.

1.6.24 The Commission was informed that EC-66 had agreed that WIGOS, supported by WIS, should continue as a WMO Strategic Priority for the next (2016–2019) financial period, with the notion that this would be designated the Pre-Operational Phase of WIGOS.

1.6.25 JCOMM-4 (Yeosu, Republic of Korea, May 2012) updated the Implementation Goals of the JCOMM Observations Programme Area (OPA), which were aligned with the ocean chapter of the GCOS Implementation Plan for the Global Observing System for Climate, in support of the UNFCCC (GCOS-138 in its 2010 update). See: http://www.jcomm.info/index.php?option=com_oe&task=viewDocumentRecord&docID=8930.

1.6.26 The Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP), that had been approved by EC-65 (Geneva, 2013), was available in English, French, Russian and Spanish, and the Chinese translation was about to be released.

1.6.27 An ad hoc workshop on Observing System Design was held, under the auspices of the IPET-OSDE, in Geneva, Switzerland from 12 to 14 November 2013, to develop Observing Systems Network Design (OSND) principles and guidance. The workshop also agreed a roadmap for the development of guidance for OSND, including the proposed role of this workshop's participants and of IPET-OSDE. OSND would be considered later during the session.

1.6.28 The Expert Team on Surface-Based Observations (ET-SBO) had successfully organized a WMO Workshop on the Regional and Global Exchange of Weather Radar Data, April 2013, hosted by the UK Met Office, as a response to action G48 of the EGOS-IP calling for wider international exchange of weather radar data. One of the key outcomes of this workshop was the recommendation to form a task team within CBS to coordinate and finalize the development of a WMO standard for international exchange of weather radar data. This recommendation had been adopted by the Commission for Basic Systems at its fifteenth session and the formation of the Task Team on Weather Radar Data Exchange was finalized in late 2013.

1.6.29 Following the efforts of Members in conducting Observing System Experiments (OSEs) and Observing System Simulation Experiments (OSSEs), the Implementation-Coordination Team of the OPAG IOS (ICT-IOS) made initial steps to organize the Sixth WMO Workshop on the Impact of Various Observing Systems on NWP in 2016.

1.6.30 As a key outcome of the Expert Team on Aircraft-based Observing Systems (ET-ABO) First Session (September 2013), ET-ABO had produced the Aircraft-Based Observations Programme Strategy and Implementation Plan (A-SIP) and was working towards the development of individual ABOP Regional Implementation Plans (A-RIP) in collaboration with each WMO

Regional Association as a component of the respective Regional WIGOS Implementation Plans. The A-SIP and each A-RIP would be based on the results of the WMO study on AMDAR Coverage & Targeting for Future Airline Recruitment that had been completed in February 2013.

1.6.31 In support of the efforts of Members to expand and improve aircraft-based observations coverage, ET-ABO has produced two important reports under the WIGOS technical *report series: (a) WIGOS Technical Report 2014-1,* The Benefits of AMDAR to Meteorology and Aviation (January 2014); and (b) WIGOS Technical Report 2014-2, *Requirements for the Implementation and Operation of an AMDAR Programme* (March 2014).

1.6.32 Noting the importance of radio frequency coordination to environmental observing systems and the importance of NMHSs contributing to the national and international radio frequency coordination activities as reflected in Resolution 4 (Cg-XV) and Resolution 11 (EC-64) on "Radio frequencies for meteorological and related environmental activities", the Steering Group on Radio-frequency Coordination (SG-RFC) has prepared a Guide to NMHS Participation in Radio Frequency Coordination for consideration of CBS to assist Members in this important activity.

Decisions of the president and CBS Management Group

1.6.33 Following the resignation of Mr Riijshogaard as chairperson of the OPAG on Integrated Observing Systems, the CBS Management Group had appointed Mr Jochen Dibbern (Germany) as chairperson and Mr Anthony Rea (Australia) as co-chairperson.

1.7 WMO priorities for 2012–2015 and Implications for the Commission (agenda item 1.7)

WMO priorities

1.7.1 The Commission recalled that the Sixteenth Congress identified five priority areas for the current financial period:

(a) Global Framework for Climate Services;

(b) Aviation meteorological services;

(c) Capacity-building for the developing and Least Developed Countries;

(d) Implementation of the WMO Integrated Global Observing System (WIGOS) and WMO Information System (WIS); and

(e) Disaster risk reduction.

1.7.2 The Commission noted the important roles it played in those priority areas, with leading roles in some areas or activities. It further noted that as the scope of activities of CBS has been extended well beyond that of the World Weather Watch, more application requirements from various programmes are to be considered, joint efforts with other technical commissions are becoming more and more necessary, therefore more effective and efficient mechanisms for collaboration with other technical commissions are needed. The Commission requested its Open Programme Area Groups (OPAGs) to take this trend into account when planning their future activities and working structures.

1.7.3 The Commission noted the publication of the *Guidelines on the Preparation and Promulgation of the WMO Technical Regulations* (WMO-No. 1127). It was considered that these Guidelines would provide the basis for enhancing the overall quality of the technical regulations in terms of consistency and homogeneity of the regulatory documents, compatibility for implementation of the provisions, style and layout. The Commission urged its OPAGs and expert teams engaged in the preparation and maintenance of technical regulations to make use of the

Guidelines in preparing and maintaining regulatory material. The Commission also noted the importance of thorough review and testing of standards before they are incorporated into Technical Regulations or formal guidance, and encouraged the use of pilots and publication of drafts on the web provided their status is stated clearly.

1.7.4 At its fifteenth session and at its joint session with the ICAO meteorological division meeting, the Commission for Aeronautical Meteorology (CAeM) had identified several areas in which it would need the assistance of CBS, most notably in the continued emphasis on quality management, observations to support response to volcanic ash, data representations, and interoperability between the WMO Information System (WIS) and the System Wide Information Management (SWIM) system being designed by ICAO. The Commission noted the impact of the ICAO System Wide Information System (SWIM) on the services required from Members, recognized that the Commission must take an active part in the development and implementation of SWIM, and urged all Members to prepare for the implementation of SWIM.

1.7.5 The Commission reviewed the relevant decisions taken by the sixty-fifth and sixty-sixth sessions of the Executive Council, the sixteenth session of the Commission for Climatology, the sixteenth session of the Commission for Instruments and Methods of Observation, and the fifteenth session of the Commission for Aeronautical Meteorology. It discussed the impact of those decisions on the future work programme of the Commission and included its conclusions in the general summary under their respective agenda items.

2. TECHNICAL DECISIONS, INCLUDING ON REVISIONS OF TECHNICAL REGULATIONS, REQUIRED TO SUPPORT PROGRAMME ACTIVITIES (agenda item 2)

2.1 Technical decisions relating to the Open Programme Area Group on Public Weather Services (agenda item 2.1)

The WMO Strategy for Service Delivery

2.1.1 The Commission noted with appreciation the development and publication of “The WMO Strategy for Service Delivery” (herein referred to as “the Strategy”) and its Implementation Plan (IP) (see agenda item 4.2). The Commission recommended that the Public Weather Services (PWS) Programme should apply the principles contained in the Strategy and its IP to assist National Meteorological and Hydrological Services (NMHSs) in promoting delivery of high quality services to user communities and in improving their skills in communicating social and economic benefits to decision-makers.

Decisions of the Commission with respect to the Open Programme Area Group on Public Weather Services (OPAG/PWS)

2.1.2 The Commission considered the major issues which had emerged from the work of the OPAG/PWS.

2.1.3 In view of the strategic priority given to service delivery in the WMO Secretariat Operating Plan (SOP, 2016–2019) and in line with the Strategy, the Commission decided that the focus of OPAG/PWS should be on “Public Weather Services for Public Safety and Welfare” (PWS for PSW) to encapsulate the role of PWS in the protection of life and property and in contributing to economic security;

2.1.4 Recognizing the benefits in fully aligning the work of the OPAG/PWS with the Strategy, the Commission endorsed the restructuring and re-naming of the PWS ETs as follows:

(a) Expert Team on User Engagement for Service Improvement (ET/UESI);

(b) Expert Team on Service Innovation and Design (ET/SID);

(c) Expert Team on Service Delivery and Communication (ET/SDC).

2.1.5 The Commission adopted Recommendation 1 (CBS-Ext.(2014)) – Competency Framework for Public Weather Services Forecasters and Advisers.

2.1.6 The Commission decided to promulgate the PWS Competencies Framework to other WMO programmes that are developing competencies in their own fields, with a view to promoting the harmonization of different competencies being developed in WMO.

2.1.7 The Commission adopted Resolution 1 (CBS-Ext.(2014)) – WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services, that would contribute to disaster reduction and mitigation activities of Members.

2.1.8 The Commission requested OPAG-PWS, and the PWS Programme, to familiarize Members with the WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services, and to assist those Members who had plans to implement impact-based forecasting, through organizing training workshops and, where possible, pilot projects to demonstrate the practical steps for moving in this direction.

2.1.9 The Commission decided that the PWS Programme should include activities: to organize regional training workshops to provide training in socio-economic assessments; where possible, develop pilot projects to implement and test the content of the publication; and to familiarize Members with the assessment of socio-economic benefits of meteorological and hydrological services provided by NMHSs, as a follow up to the publication of the joint WMO-World Bank book on the same subject in December 2014 (see paragraph 2.1.21 below);

2.1.10 The Commission strongly encouraged the engagement of Members in: (i) the “WMO Register of Alerting Authorities” initiative; and (ii) adopting the Common Alerting Protocol (CAP) technology for communicating weather warnings and alerts, and in this connection, to promote the WMO Alert Hub as a service that complemented the international Register of Alerting Authorities to reinforce the principal of a single authoritative voice for alerting.

2.1.11 The Commission decided to further strengthen the PWS component of the SWFDP to enhance the delivery of high quality warning and forecast services to users, thus ensuring the full realization of the benefits of all current and future Severe Weather and Forecasting Demonstration Projects (SWFDP)-related activities.

2.1.12 The Commission decided to provide further assistance to NMHSs in strengthening their links with media in support of more effective dissemination of warnings of severe weather, and their impacts, to the general public.

2.1.13 The Commission requested the OPAG-PWS to continue to closely collaborate with the OPAG-DPFS within the framework of the CBS Task Team on the Provision of Operational Meteorological Assistance to Humanitarian Agencies.

Overview of the OPAG/PWS activities

Expert Team on Services and Products Innovation and Improvement (ET/SPII)

2.1.14 The Commission noted that the ET/SPII met in Hong Kong, China in May 2014. The major deliverables set by the Team were to: (i) analyse the responses to a questionnaire designed to gather information on nowcasting systems and their use in NMHSs (already distributed to Members); (ii) to develop training material on forecast uncertainty; to examine the “Big Data” problem in meteorology and how to make best use of data for forecasters; (iii) to examine the cost benefits and utility of mobile Apps in service delivery; and (iv) and to study the needs of NMHSs for Geographical Information Systems (GIS)-based spatial data and services. The Commission endorsed these as important areas of work in the innovation and impact of public weather services.

Expert Team on Communication, Outreach, and Public Education Aspects of PWS (ET/COPE)

2.1.15 The Commission was informed that the ET-COPE held its intersessional meeting in Nanjing, China, October–November 2013. The major deliverables agreed by the Team were to: (i) prepare Summary Guides for NMHSs on using social media, on communicating socio-economic benefits of PWS, and on conducting outreach PWS activities; (ii) prepare Guidelines on assisting NMHSs to develop a corporate external communication strategy designed to promote their visibility and value; and (iii) develop an on-line survey designed to measure the use of different media for PWs delivery. The Commission looked forward to the final outcome of the work of the Team.

Expert Team on Meeting User Needs in Reducing the Impacts of Hydrometeorological Hazards (ET/DPM)

2.1.16 The Commission noted that the meeting of the ET-DPM was held in Flic en Flac, Mauritius, September 2013. The major deliverable set by the Team was to finalize the WMO Guidelines on Multi-Hazard Impact-Based Forecast and Warning Services. A supplementary deliverable identified at this meeting was to “Develop training requirements for Early Warning Systems and Impact-Based Forecasting”.

Implementation Coordination Team (ICT/PWS)

2.1.17 The Commission noted that the ICT-PWS had met in Melbourne, Australia in June 2014. It had reviewed the work of the PWS ETs, and held extensive discussions on the future direction of the OPAG-PWS and CBS-related activities. The Team considered in particular the visibility generated within WMO of the issue of service delivery, particularly after the approval and publication of the Strategy and its IP. It deliberated on how to promote service delivery and progress its implementation within the framework of the PWS Programme while at the same time keeping the focus on the articulated mandate of PWS and its brand. It agreed to the re-naming of the Expert Teams to fully align them with the service delivery stages as articulated in the Strategy (see paragraph 2.1.4 above) and provided overarching guidance to the individual Expert Teams on re-defining their Terms of Reference (TORs), which would need to be carefully considered by the Teams as they re-draft their TORs for approval by the Commission. In addition, the ICT reviewed the PWS competencies, which had been already reviewed by several other groups including the Executive Council Panel on Education and Training, and made some further improvements to the competency requirements for the PWS forecaster.

World Weather Information Service (WWIS) and Severe Weather Information Centre (SWIC)

2.1.18 The Commission noted that WWIS was available in ten language versions as follows, with host Members in brackets: Arabic (Oman), Chinese (China), English (Hong Kong, China), French (France), German (Germany), Italian (Italy), Polish (Poland), Russian (Russian Federation), Portuguese (Portugal), and Spanish (Spain), and that the number of cities for which forecasts were provided had increased to over 1,700. The Commission welcomed the outcomes of the Fourth Meeting of the WWIS Hosts (Warsaw, Poland, 2013), at which important decisions were reached to enhance the WWIS website, as a result of which the WWIS version 2.0. was launched during the sixty-sixth session of the Executive Council (EC-66, Geneva, June 2014). The new version boasted several new features which made the website even more user-friendly, useful and easy to navigate. The SWIC website continued to provide a global view of tropical cyclones plus several other hazards, such as thunderstorms and observed fog. The Commission strongly encouraged Members to make use of these sites and, in particular, increase their contributions to the WWIS website.

WMO Alert Hub

2.1.19 The Alert Hub technology as implemented on the extensive and highly capable worldwide cloud infrastructure was of great value to emergency alerting. In facilitating access to alerts, the Alert Hub service addressed crucial requirements of emergency alerting for the highest

levels of responsiveness, availability, reliability, authenticity, and security. The Alert Hub satisfied these requirements without compromising authority because alerts facilitated by the Alert Hub remained clearly a product of the alert issuer, and the Alert Hub did not originate alerts; it only helped disseminate alerts. The Commission endorsed the establishment of the Hub as an additional mechanism in the application of a single official voice principle.

2.1.20 The Commission also noted the value of having information on a WMO Alert Hub and the continuing effort by the United States National Oceanic and Atmospheric Administration (NOAA) towards defining and establishing a WMO Alert Hub. The purpose of the Hub was to enhance the global accessibility of authoritative alerts for any type of hazard threat. The WMO Alert Hub had been implemented as a content subset of the less specialized Alert Hub (http://alert-hub.appspot.com/publishers) operated as a free service on the worldwide cloud infrastructure. An Alert Hub aggregated in one location many emergency information data feeds from sources throughout the world. The distinctive feature of the WMO Alert Hub was that alerts accessible through it were limited to those alerts published by authoritative sources registered in the international Register of Alerting Authorities (http://www.wmo.int/alertingorg) whereas the less specialized Alert Hub intended to contain alerts from other sources as well. In this regard, the WMO Alert Hub would be made publicly accessible through a URL address associated to WMO (e.g., https://www.wmo.int/alert-hub).

Social and Economic Applications of PWS

2.1.21 The Commission stressed the importance of assessing socio-economic benefits of the services provided by Members and strongly supported the work of the OPAG and the PWS Programme in this area. It commended the progress in the project to prepare an authoritative joint WMO-World Bank book on methodologies for assessment of such socio-economic benefits, which would be published in December 2014. In addition, the Commission stressed the importance of effectively communicating socio-economic benefits of the services provided by Members to their governments and other decision-makers and requested adequate guidance by the PWS on this aspect. The Commission encouraged Members to apply the methods contained in the publication to determine the benefits of the services they provide, which were underpinned by the Basic Systems, and requested the OPAG-PWS to provide Members with guidance on conducting socio-economic benefit studies at national and regional levels.

Capacity development

2.1.22 The Commission welcomed the capacity development activities of the PWS Programme, which included a number of training events since the fifteenth session of the Commission for Basic Systems (CBS-15, Jakarta, Indonesia, September 2012), and the preparation of a number of guidance materials. The full list of the events can be viewed at: http://www.wmo.int/pages/prog/amp/pwsp/eventsworkshops_en.htm.

2.2 Technical decisions, including on regulations, managed by the Open Programme Area Group on Data-processing and Forecasting System (agenda item 2.2)

Technical Regulations managed by OPAG-DPFS

2.2.1 The Commission recalled that the Fifteenth World Meteorological Congress (Cg-XV, 2007) recognized the successes of the WMO cooperation with the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), and that the collaboration on atmospheric transport backtracking modelling had been fully developed and tested for implementation. Within a couple of years thereafter, the Joint CTBTO-WMO ATM – Backtracking Response System had been fully implemented, and System's technical aspects were included into the *Manual on the Global Data Processing and Forecasting System (GDPFS)* (WMO-No. 485). The Commission also recalled that nine RSMCs have been designated by WMO to participate in the Joint Response System. The Commission was pleased to note that RSMC Washington had conducted with CTBTO a variety of functionality tests to confirm its backtracking capability, compliant with all the mandatory functions, as described in the *Manual on the GDPFS*. In this context, the Commission recommended their

formal designation, and therefore proposed an amendment to the *Manual on the GDPFS*, as found in Annex 1 to Recommendation 2 (CBS-Ext.(2014)).

2.2.2 Noting the results of the work of the CBS/DPFS Expert Team on Emergency Response Activities as a follow up to the Fukushima Daiichi NPP accident (Japan, 2011) and the longstanding WMO cooperation with IAEA and CTBTO, the Commission proposed an amendment to the *Manual on the GDPFS* related to the regional and global arrangements for: (a) the provision of transport model products for environmental emergency response; and (b) atmospheric backtracking, as found in Annex 2 to Recommendation 2 (CBS-Ext.(2014)).

2.2.3 The Commission noted the completion of demonstration phases of the RCC Africa hosted by ACMAD (RA I) and RCC WSA hosted by CIIFEN (RA III) operations that had provided evidence that they had complied with all the mandatory functions, as described in the *Manual on the GDPFS*. In this context, the Commission recommended their formal designation, and therefore proposed an amendment to the *Manual on the GDPFS*, as found in Annex 3 to Recommendation 2 (CBS-Ext.(2014)).

2.2.4 Considering the above, the Commission adopted Recommendation 2 (CBS-Ext.(2014)) – Amendments to the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485).

2.2.5 The Commission noted that a Task Team on the Revision of the WMO Technical Note 170 (TT-TN170, entitled: "Meteorological and Hydrological Aspects of Siting and Operations of Nuclear Power Plants") had been established, involving relevant WMO Technical Commissions (i.e. CBS/OPAGs on DPFS (leader) and IOS, CCl, CHy, and JCOMM) and the International Atomic Energy Agency (IAEA). The Commission acknowledged the TN170 document framework plan (aligned with the IAEA Specific Safety Guide: "Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Facilities" (SSG-18, 2011, jointly sponsored with WMO)), as given in Annex I to the present report, and urged the completion of the revision of this publication for consideration at CBS-16. The Commission agreed that the revised publication would provide scientific and technical guidance on the access to, and analysis, interpretation and use of, meteorological and hydrological information on hazards, including the relevant aspects of climate variability and change, to support the assessment of the associated impacts on the safety of nuclear installations as well as the planning and risk management efforts concerned, as described in the SSG-18.

2.2.6 The Commission noted that the Regional Association II (RA II) had strongly encouraged China to realize its plans related to sand and dust storm-related services and recommended a demonstration of operational forecasting capabilities, to serve Members of the eastern part of RA II in dust monitoring and forecasting. The Commission acknowledged the efforts by SDS-WAS Regional Node in Asia in the development of the Asian SDS-WAS portal, data exchange and data policy, and model intercomparison, and therefore requested China, in collaboration with the relevant SDS-WAS Regional Node in Asia, to prepare an assessment document to demonstrate its capabilities in operational sand and dust storm forecasting. The Commission also requested OPAG-DPFS, in collaboration with the SDS-WAS Steering Committee, to coordinate the assessment of the capabilities against the designation criteria stated in the *Manual on the GDPFS* (WMO-No. 485), prior to its formal recommendation for designation. The Commission agreed that the president of CBS would seek approval for designation by the Executive Council based on the positive result of the assessment.

New Manual on the Global Data-processing and Forecasting System (GDPFS)

2.2.7 The Commission recalled that Sixteenth Congress had adopted the outline for a revised *Manual on the GDPFS* (WMO-No. 485) through Resolution 6 (Cg-XVI), wherein it decided that this Manual would be the single source of technical regulations for all operational data-processing and forecasting systems operated by WMO Members. The Commission noted with appreciation that the revision of the Manual was near completion, and acknowledged the active cooperation and enhanced coordination among the relevant technical commissions and partner organizations in incorporating aspects related to all WMO data-processing and forecasting systems in the revised

Manual on the GDPFS. It also noted that the revised Manual would, at its completion, conform to the principles and procedures contained in: *Guidelines on the Preparation and Promulgation of the WMO Technical Regulations* (WMO-No. 1127, 2014).

2.2.8 The Commission also recalled that at its fifteenth session it had noted that the new Manual introduced a number of changes to the current procedures, and that the new Manual would most likely be in force by 2015. In this context, and recalling its request at its fifteenth session, the Commission acknowledged the comprehensive summary of changes of functions and procedures that would ensure the smooth transition, as given in Annex II to the present report.

2.2.9 The Commission acknowledged that the new Manual was being developed in accordance to quality management principles and agreed that it would facilitate the review of compliance of GDPFS Centres against the designation criteria, which include, amongst others, forecast verification activities. However, recognizing that some GDPFS centres may report temporary non-compliance with regard to some of the requirements, mainly because of resource constraints during system development or adaptation, the Commission recommended a transition plan for the implementation of the new Manual (that would replace the current version) to manage the technical changes and the initial designation of the GDPFS centres as defined in the new Manual, including WMCs and RSMCs. The Commission therefore adopted Recommendation 3 (CBS-Ext.(2014)) – Introduction of the new *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485). In order to facilitate the review process of the new Manual, prior to its consideration by a WMO constituent body, the Commission invited WMO Members to review the draft version of the new Manual (which would be available from beginning February 2015 on the WMO website at http://www.wmo.int/pages/prog/www/DPS/linkedfiles/Revised-Manual-forReview.zip and provide their comments to the WMO Secretariat (by email to dpfsmail[at]wmo.int) by June 2015.

2.3 Technical decisions, including on regulations, managed by the Open Programme Area Group on Information Systems and Services (agenda item 2.3)

Management of the Global Telecommunications System

2.3.1 The Commission thanked the Chair of OPAG-ISS, Mr M. Dell'Acqua (France) for his report, and the experts who contributed to the activities of OPAG-ISS. The Commission noted that the Global Telecommunications System (GTS) remained a key component of the WMO Information System (WIS), that an up-to-date description of the connectivity between centres was important for efficient and effective operation of the GTS, that with changes in technology were reducing the need for regional practices, and that Volume II of WMO-No. 386 *Manual on the Global Telecommunication System* was not regulatory. The Commission therefore recommended that information should either be published in WMO-No. 386 Volume I if it was regulatory, or on the WMO website if it was not, and that Volume II should be discontinued (see Recommendation 4 (CBS-Ext.(2014)). The Commission further recognized the need of NWP centres for data that were only contained in the parts of the message designated for national or regional distribution. It requested Members, in particular RTHs, not to remove regional or national information from messages forwarded for global distribution.

2.3.2 The Commission noted that the President of WMO had approved the use of bulletin headers with data designators (T1T2) of LC, LT, LA, LP, LC, LS and LV for use with information for international civil aviation provided in extensible markup language (XML). The Commission approved the additional data designators in Recommendation 4 (CBS-Ext.(2014)) – Amendments to the *Manual on the Global Telecommunication System* (WMO-No. 386).

All Hazards network

2.3.3 The Commission noted the successful participation of Mr Kenji Tsunoda (Japan), Co-chair ICT-ISS, in the IOC Tsunami Warning Services, in particular its use of the GTS for the delivery of Tsunami guidance, alerts and warning messages to relevant alerting authorities. The Commission noted the importance of continued WIS representation in IOC Intergovernmental

Coordination Group meetings in ensuring WIS was able to provide the necessary secure distribution of information to all authorized recipients. It noted that the Tsunami service information exchange supported by WIS was an ideal pilot for the refinement of the "All Hazards Warning Network" and for making use of the greater flexibility in WIS to provide information beyond the limits of the traditional GTS.

Data Representation

Amendments to the Manual on Codes between sessions

2.3.4 The Commission noted with satisfaction that several amendments to WMO-No. 306 *Manual on Codes – International Codes,* Volume I.2: *Part B and Part C* had come into force between CBS sessions in accordance with the Procedures for Amending the Manual on Codes (Res. 7 (EC-LXI)).

(a) Amendments by procedure between CBS sessions (7 November 2012, partially 6 November 2013);

(b) Amendments by fast-track procedure (7 November 2012);

(c) Amendments by fast-track procedure (8 May 2013);

(d) Amendments by procedure between CBS sessions (14 November 2013);

(e) Amendments by fast-track procedure (14 November 2013);

(f) Amendments by fast-track procedure (7 May 2014);

(g) Amendments by procedure between CBS sessions (Already approved and to be implemented on 5 November 2014);

(h) Amendments by fast-track procedure (underway to be implemented 5 November 2014).

2.3.5 The Commission recognized that these procedures had brought a great flexibility on amending WMO-No. 306 *Manual on Codes – International Codes*, *Volume I.2: Part B and Part C* not only for introducing new entries in tables of Table Driven Code Forms (TDCF) on a timely basis, but also for synchronized implementation of aeronautical codes with amendments to ICAO Annex 3 (Annex 3 to the Convention on International Civil Aviation, which was equivalent to WMO-No. 49 Technical Regulations, Volume II: *Meteorological Service for International Air Navigation*).

Provision of support for changes to data representation following amendments to ICAO Annex 3

2.3.6 The Commission noted that the sixty-second session of Executive Council (Geneva, June 2010, paragraph 3.5.2.1) invited CBS to ensure that the amendments implemented under the procedure for adoption of amendments between CBS sessions were "limited to those that do not create an additional financial burden on Members nor pose operational problems"; changes to codes to be consistent with WMO-No. 49 Technical Regulations, Volume II: *Meteorological Service for International Air Navigation* were often not permitted under this route.

2.3.7 In most cases, WMO Members were also ICAO Contracting States. This means that they would have been consulted on, and been able to take part in, the approval process for amendments to ICAO Annex 3, including those that had financial or operational impacts. Members would have had the opportunity to consider financial and operational implications during the ICAO approval procedure. The Commission considered that there would be minimal additional risk to Members arising from using procedure for adoption between CBS sessions for amendments to WMO-No. 306 *Manual on Codes – International Codes, Volume I.1: Part A – Alphanumeric Codes* or WMO-No. 306 *Manual on Codes – International Codes, Volume I.2: Part B and Part C* and the

future WMO-No 306 *Manual on Codes – Representations derived from data models, Volume I.3: Part D* resulting from the amendments to ICAO Annex 3. The Commission adopted Recommendation 5 (CBS-Ext.(2014)) – Authorizing use of the procedure for amending Manuals between sessions of the Commission for Basic Systems in response to amendments to Annex 3 to the Convention on International Civil Aviation.

2.3.8 The conjoint meeting between CAeM and the ICAO Meteorology Division had been held in July 2014. This meeting agreed a long-term vision that by 2025 meteorological information required for international civil aviation would be available in a flexible manner that would simplify its use in combination with other information required to manage international civil aviation operations. Intermediate objectives had been set of making exchange of METAR and SPECI (including trends), TAF and SIGMET MXML recommended practices from 2016, and standard practice from 2019 (or 2018 if ICAO changes its regulatory cycle from three years to two years). Amendment 77 to Annex 3 was expected to extend the types of report that may be exchanged in extensible markup language (XML) to all reports in Annex 3 with effect from 2019. At its fifteenth session, the Commission for Aeronautical Meteorology had asked CBS to support capacity development of Members to allow them to generate and use XML data representations. The Commission considered that introducing XML as a standard practice on the required time scales was a challenging requirement that would need significant resources.

2.3.9 The original terms of reference of the Task Team on Aviation XML (TT-AvXML) included only development of standards to support Amendment 76. The Commission added capacity development and the additional requirements expected to be included in Amendment 77 to the tasks of TT-AvXML, noting that it would require additional team members with skill in capacity development issues. The Commission also noted that CAeM had created an Expert Team on Information and Services for Aviation (ET-ISA), and asked that a member of that team should act as coordinator with TT-AvXML. Noting further that the costs of developments in support of international civil aviation regulations should largely be recoverable by Members, the Commission agreed to amend the terms of reference as shown in the Terms of Reference of the Task Team on Aviation XML in Annex III to the present report.

Amendments to Regulations for reporting traditional observation data in TDCF: BUFR or CREX

2.3.10 The Commission noted with concern that there remained ambiguities in regulations for reporting traditional observation data in Table-Drive Code Forms (TDCF), specifically in reporting cloud information within surface observations, and in reporting date and time based on regional reporting practices of CLIMAT. The Commission adopted Recommendation 6 (CBS-Ext.(2014)) – Amendments to the *Manual on Codes* (WMO-No. 306), Volume I.2 – Amendments to Regulations for reporting traditional observation data in Table Driven Code Forms: BUFR or CREX.

Amendments to Regulations of FM 94 BUFR

2.3.11 The Commission also noted that there was ambiguity in the instructions for BUFR messages when indicating that a character string was missing. The Commission recognized that missing character strings needed to be reported in a consistent way in BUFR messages and adopted Recommendation 7 (CBS-Ext.(2014)) – Amendments to the *Manual on Codes* (WMO-No. 306), Volume I.2 – Representation of missing character strings.

Reporting zero snow depth

2.3.12 Ground-based snow observations were important for monitoring, model validation, validation of satellite-derived data, and increasingly for assimilation into numerical weather prediction models. The Commission noted, however, that snow depth was generally reported only when snow was present and this led to an ambiguity in that users could not distinguish between missing snow depth data meaning *no snow* or meaning *no observation due to a technical problem at the station*, for instance an instrument failure or system outage. This had been identified as an issue by the Global Cryosphere Watch (GCW) Snow Watch initiative.

2.3.13 Explicit reporting of zero snow depth was standard practice in TDCF but was not possible in Traditional Alphanumeric Codes (TAC). The Commission had already decided that the TAC should not be changed, but recognized that the TAC were often used for collecting observations nationally. The Commission agreed to facilitate reporting zero snow depth by suggesting that those Members using TAC nationally might consider using the unallocated entry 000 of code table 3889 to indicate zero snow depth, so that the information would be available when national reports are converted to TDCF.

Progress with migration to Table Driven Code Forms

2.3.14 The Commission regretted that although many Members were exchanging World Weather Watch information in TDCF, there were still many reports that were only available in TAC. The Commission noted that ECMWF published an interactive wiki page "TAC To BUFR Migration" that is accessible in view mode under https://software.ecmwf.int/wiki/display/TCBUF/TAC+To+BUFR+Migration that contained information on the availability, completeness, timeliness, duplicates and the structure of BUFR and TAC data The page also linked to the latest version of the program synop2bufr.

2.3.15 In view of the short time until the November 2014 date for completion of migration, and of the risks of attempting to implement rapid changes, the Commission recommended that data providers produce reports in both TAC and BUFR for an overlap period of two months with the intention of completing migration within six months. The Commission asked OPAG-ISS to review progress with migration every six months and to consider whether a further of extension of six months was required to resolve issues with the consistency and quality of data.

2.3.16 At its Extraordinary Session in 2010, the Commission had confirmed the time table for migration to TDCF. That plan included an end to parallel exchange of information in both TAC and TDCF in November 2014, permitting only TDCF to be distributed from then on. The Commission considered that no changes were necessary to the migration matrix in Annex IV to the present report. It felt, however, that the following measures were needed to facilitate and complete the migration:

(a) Migration activities may continue after the expiration of the dates given in the migration matrix. However, the risks associated with the reliance on TAC increase substantially as the migration approached its conclusion. The plan would be maintained as is in order to stress the importance of the committed time table;

(b) All Members should make available their plans for migration including key dates;

(c) Members must remove inconsistencies between the location of stations listed in WMO-No. 9, Volume A, *Weather Reporting – Observing Stations* and the locations of stations reported in TDCF;

(d) Quality checking and validation of BUFR bulletins was needed, including comparison of BUFR messages with their TAC equivalent;

(e) A procedure was needed for reporting and addressing issues arising from the migration;

(f) Noting the imminent November 2014 deadline, IPET-DRMM should prepare a report to be sent to Permanent Representatives of Members with WMO to communicate migration successes and remaining issues;

(g) The reporting of progress and issues by Member states should be encouraged, and it was noted that regional associations can play a role by creating a framework for MTDCF reporting and support;

(h) Migration issues should be identified separately from difficulties in getting data from observation sites to RTHs, although resolving the latter remains high priority;

(i) OPAG-ISS should provide further assistance to Members on issues relating to migration.

Definition of completion of migration

2.3.17 Noting that TAC would continue to be exchanged after November 2014, the Commission adopted the following definition of completion of migration:

(a) WMO no longer maintained the World Weather Watch Traditional Alphanumeric Codes (but OPMET codes would be maintained as long as ICAO requires them);

(b) All centres using information that was exchanged on the GTS Main Telecommunications Network could operate based on the TDCF information flow;

(c) No National Centre was required to produce information in TAC for the purpose of GTS exchange.

2.3.18 Noting progress with migration to Table Driven Codes Forms and the request from CBS-Ext.(10) for Regional Telecommunications Hubs to convert between TAC and TDCF on behalf of Members, the Commission concluded that Members adding new reports onto the GTS should only do so using TDCF. The Commission adopted Recommendation 8 (CBS-Ext.(2014)) – Migration to Table Driven Code Forms.

World Weather Watch Quantitative Monitoring

2.3.19 The Commission noted the results of the World Weather Watch quantitative monitoring. It regretted the low level of availability of information from some areas, particularly upper-air information. The Commission was concerned that the monitoring statistics show that many stations listed in the Regional Basic Synoptic Networks for both surface and upper-air did exchange surface observations, but they did not exchange upper-air information.

2.3.20 The Commission noted that the standard monitoring only captured statistics on information reported by stations in the relevant Regional Basic Synoptic Networks and reported at the times required by these networks, so that in some cases observations were being made and reported but the reports were not included in the statistics. The Commission urged Members whose stations were labelled by the monitoring as under-reporting to identify the reasons for this and rectify them if possible.

2.3.21 The Commission noted with concern that some centres running numerical weather prediction systems had found that the locations of some stations being reported in BUFR reports were significantly different from the locations recorded in WMO-No. 9, Volume A, *Weather Reporting – Observing Stations*. The Commission recommended that centres running operational numerical weather prediction models continue to investigate persistent problems with observations, and urged all Members to validate the contents of reports they prepare in TDCF and to correct any errors in WMO-No. 9, Volume A, *Weather Reporting – Observing Stations*.

2.3.22 Reports from land stations in Traditional Alphanumeric Codes did not contain location or other station metadata and rely on WMO-No. 9, Volume A for this information. The Commission requested the Secretariat to consider publishing on the web past versions of WMO-No. 9, Volume A, *Weather Reporting – Observing Stations* and associated metadata to assist those using historical observations.

Satcom Initiative

2.3.23 The Commission noted that the ad hoc international forum of users of satellite data telecommunication systems was held at the headquarters of the Intergovernmental Oceanographic Commission (IOC) of UNESCO in Paris, France, from 3 to 4 October 2013. The forum included 33 participants from 12 countries. Representatives of the satellite data telecommunication service

providers, and the satellite equipment manufacturers also attended the meeting. It recalled the EC-66 request to review the reports of the initial ad hoc satellite data telecommunications systems (Satcom) meetings for consideration by Cg-17, including assessment of budget implications associated with the organizational and operating practices should a Forum be established.

2.3.24 The Commission noted the potential benefits of establishing such an international mechanism in partnership with IOC and other potential co-sponsoring organizations, to address remote data collection and communication requirements, including tariff negotiations as needed, for automatic environment observing systems using satellite data telecommunication systems. Noting further that the proposed forum was to be self-funded participation by stakeholders, the primary cost would be secretariat support which was proposed to be provided by co-sponsoring organizations on a rotating basis. This was estimated to be on average around CHF 10,000 per annum for each co-sponsor. The Commission adopted Recommendation 9 (CBS-Ext.(2014)) – Establishment of a SATCOM Users' Forum.

2.3.25 The Commission noted the potential benefits to Members of establishing a close alliance between the SATCOM forum and the Joint Tariff Agreement Argos and encouraged earlier dialogue amongst the various stakeholders to consider how such an alliance could be developed.

Model driven data representations

2.3.26 The Commission noted that, on behalf of ICAO and CAeM, the Task Team on Aviation XML had developed a representation in extensible markup language (XML) of the information content of TAF, METAR, SPECI and SIGMET reports. These representations were based on the ISO 19156 "Observations and Measurements" standard. It further noted that in developing this representation the team had sought and responded to comments from WIS and data representation focal points, and that an experimental version (1.0) had been provided for use by the international civil aviation community in November 2013. Subsequent feedback from OPAG-ISS expert teams resulted in proposed changes that had been included in the draft of version 1.1 in Recommendation 10 (CBS-Ext.(2014)). The Commission adopted Recommendation 10 (CBS-Ext.(2014)) – Representation of aviation information in extensible markup language.

2.3.27 WaterML2 was an XML representation of water data that was being developed by the Commission for Hydrology (CHy) and the Open Geospatial Consortium. The Commission endorsed the proposal from IPET-MDRD that WMO-No. 306 The *Manual on Codes* Volume I.3 would be the appropriate document in which to define other model-driven data representations, including WaterML2, that may be adopted in the future.

2.4 Technical decisions, including on regulations, managed by Open Programme Area Group on Integrated Observing Systems (agenda item 2.4)

Revision and Harmonization of the Manual on the GOS

2.4.1 The Commission was pleased with the update of the *Manual on the Global Observing System*, Volume I – Global Aspects (WMO-No. 544), which had been finalized by IPET-WIFI under the capable leadership of Mr Russell Stringer (Australia). The Commission adopted Recommendation 11 (CBS-Ext.(2014)) – Revised *Manual on the Global Observing System* (WMO-No. 544).

Radio Frequency Matters

Preparation for WRC-15

2.4.2 The Commission noted the progress on the preparation for the International Telecommunication Union (ITU) World Radiocommunication Conference 2015 (WRC-15). It noted the concerns of EC-66 relating to the potential impacts of WRC-15 decisions relating to WRC-15 Agenda Item 1.1 on International Mobile Telecommunications. It further noted that the guidance to ITU Member States on WRC-15 Agenda was available to those with access to ITU's document

system. The Commission requested the Steering Group on Radio-Frequency Coordination (SG-RFC) to review the draft WRC-15 Conference Preparatory Meeting Report, taking into consideration the concerns of EC-65 and to update the WMO Position Paper on WRC-15 Agenda as soon as possible for the guidance of National Meteorological and Hydrological Services (NMHSs) and submission to the second WRC-15 Conference Preparatory Meeting as well as other WRC-15 related preparatory meetings.

Matters for consideration by the Seventeenth WMO Congress

2.4.3 The Commission recalled Resolution 4 (Cg-XV) and Resolution 11 (EC-64) on "Radio frequencies for meteorological and related environmental activities" which identified frequency coordination activities as a matter of high priority. Noting that the demand on radio spectrum continued to increase, the Commission expressed its appreciation to the CBS Steering Group on Radio-frequency Coordination for its continued diligence and efforts in managing the very specialist issue of radio frequency coordination. The Commission adopted Recommendation 12 (CBS-Ext.(2014)) – Radio frequencies for meteorological and related environmental activities.

2.4.4 The Commission endorsed the draft of the NMHS Guide to Participation in Radio Frequency Coordination. It noted the need expressed by the Executive Council at its sixty-fourth session for this guide and the request of Resolution 9 (EC-65) for effective participation of NMHSs in national and international frequency coordination processes. The Commission encouraged Members to use this Guide in enhancing their participation in the current and future WRC preparations. It adopted Recommendation 13 (CBS-Ext.(2014)) – Guide for National Meteorological and Hydrological Services Participation in Radio-frequency Coordination.

2.5 Technical decisions, including on regulations, supporting the Space Programme (agenda item 2.5)

Cross-cutting dimension of the Space Programme

2.5.1 The Commission recalled the vital role of satellite observations from various orbits for permanent weather monitoring, nowcasting and very short-range forecasting and recognized that space-based observations cut across all component observing systems of the WIGOS, with satellite capabilities contributing to observing and monitoring climate and climate change, atmospheric composition, hydrological and cryosphere variables, space weather, etc., in addition to meteorology and oceanography.

2.5.2 In this regard, the Commission recognized the respective roles of the Expert Teams on Satellite Systems (ET-SAT) and on Satellite Utilization and Products (ET-SUP). ET-SAT was providing advice from a satellite operator's perspective, consolidating the inputs from participating agencies and the outcomes of the Coordination Group for Meteorological Satellites (CGMS) and the Committee on Earth Observation Satellites (CEOS). In order to underscore the articulation between ET-SAT, CGMS and CEOS, the Commission agreed new Terms of Reference of ET-SAT as contained in Annex V to the present report. In a complementary manner, ET-SUP addressed the users' perspective, which was essential to promote the efficient use of satellite capabilities across all WMO Regions and Programme areas. To effectively carry out this function, the relationships between ET-SUP and service-oriented technical commissions (such as CCl, JCOMM, CAgM and CAeM) and programmes needed strengthening. The Commission therefore decided to transform ET-SUP into an Inter-Programme Expert Team, as described in Annex VI to the present report.

Continuity of the WIGOS Space Component

2.5.3 The Commission was informed on the outcome of the 42nd session of CGMS in Guangzhou, China with respect to the progress of satellite programmes and the annual assessment of risks to the continuity of space-based observations.

2.5.4 The Commission acknowledged the plans from EUMETSAT and NOAA to maintain polar-orbiting operational satellites in morning and afternoon orbits respectively and noted with appreciation that China Meteorological Administration (CMA) had undertaken the government approval procedure for deploying a FY-3 satellite on the early morning orbit, thus leading to a three-orbit polar-orbiting constellation with full atmospheric sounding capabilities by 2017. The Commission was pleased to note the excellent performance of Suomi-NPP as the primary space craft on the mid-afternoon orbit and invited NOAA to take appropriate measures to mitigate the risk of a gap upon the transition from Suomi-NPP to JPSS-1 and JPSS-2. It expressed appreciation to EUMETSAT for the tandem operation of Metop-A and Metop-B on the mid-morning orbit and for the definition of EPS Second Generation, and it urged EUMETSAT and its Member States to initiate this new programme in time to ensure continuity after the EPS programme.

2.5.5 The Commission welcomed the measures taken by NOAA to implement the new NOAA GOES-East optimized imaging schedule. The Coordination Group on Satellite Data Requirements for Region III and Region IV (SDR) was instrumental in developing the schedule to meet user needs in the region. It also stressed the need to allow a seamless transition to the data, products and services (including Data Collection Systems) of the new generation GOES-R. In this regard, it noted the recommendation from ET-SUP to consider pre-operational dissemination of selected GOES-R data by independent means during an extended check-out period and during the early years of GOES-R operation, as a risk reduction measure for South America users who would not be ready to operate a GRB direct readout station. The Commission recommended that the SDR monitor the GOES-N,O,P to GOES-R,S transition and coordinate the related activities. NOAA will provide users with more details at the 2015 NOAA Satellite Conference.

2.5.6 The Commission noted that by the end of 2016 EUMETSAT would terminate the operations of Meteosat-7 over the Indian Ocean, since this satellite had to be de-orbited. These satellite observations were addressing essential WMO requirements, as the Indian Ocean modulated climate variability over Africa and was a source of severe weather systems on the Indian Ocean islands and large parts of Eastern and Southern Africa. The Commission was informed that the WMO Executive Council at its sixty-sixth session had encouraged China, EUMETSAT, India and the Russian Federation to develop a coordinated plan to secure Indian Ocean geostationary coverage after the decommissioning of Meteosat-7 in 2016. It also noted that CMA and EUMETSAT had agreed on an arrangement to consider the future provision of a replacement service, and that India had successfully launched and initiated operation of INSAT-3D.

2.5.7 The Commission looked forward to the launch of Jason-3 in 2015 to pursue ocean surface topography observation, and to the deployment of the two COSMIC-2/Formosat-7 constellations in 2016 and 2018. It welcomed the launch of GPM-Core Observatory by NASA and JAXA, and of OCO-2 by NASA, welcomed the launch of Meteor-M N2 by Roshydromet, and looked forward to the planned launch of SMAP by NASA in 2014, and Sentinel-3 by Europe and DSCOVR by NOAA in 2015.

2.5.8 The Commission was pleased to note the increased level of coordination among satellite operators. It recalled, however, that satellite missions were only contributing to the WMO Global Observing System to the extent that data were available in a timely manner to the users. The Commission encouraged EUMETSAT to collaborate with China and with India towards near real-time dissemination of scatterometer data from HY-2 and from the future ScatSat respectively. Also, the Commission encouraged the Russian Federation to make global data from Meteor-M N2 available to the WMO community in near real-time.

GSICS

2.5.9 The Commission welcomed the progress of the Global Space-based Inter-calibration System (GSICS). It confirmed the importance of GSICS for WIGOS, as a collaborative framework among satellite operators and science teams to develop, implement and share best practices, standards, procedures and tools to monitor, improve and harmonize the calibration of environmental satellites throughout the WIGOS space-based component. The Commission

encouraged GSICS to ensure the availability of well characterized, on-orbit calibration reference standards, and to provide traceability to these references. It supported the view that GSICS should focus on systematic generation of in-orbit inter-calibration information to refine the individual calibration of Level 1 satellite data, while the validation of derived products is best performed by thematic application communities. The Commission considered that GSICS was providing support both to satellite operators, in assessing the uncertainty of calibration methods and sharing knowledge and tools, and to satellite users, in enabling time-consistent, comparable, traceable climate data records. This was required to ensure interoperability within WIGOS and to support climate applications. The Commission underlined the potential of future missions in Highly Elliptical Orbits (HEO) to support intercalibration. It also welcomed the emerging collaboration between GSICS, the GCOS Reference Upper-Air Network (GRUAN) and the GNSS-RO community to provide highly accurate reference observations, as part of the WIGOS Implementation Plan. The Commission encouraged GSICS to make its operational calibration products more visible and to enhance interaction with users.

Evolution of the space-segment

Vision of the space-based observing system in 2040

2.5.10 The Commission welcomed the initiative to develop a new Vision of WIGOS component observing systems in 2040. It encouraged IPET-OSDE, in consultation with ET-SAT, ET-SUP and other groups, to update the space-based component of the current Vision taking into account the advances in remote-sensing and satellite technology, the increasing maturity of space applications (e.g. to air quality, hydrology, and cryosphere monitoring), the diversity of orbits and mission concepts required for a balanced and robust space-based observing system.

Architecture for Climate Monitoring from Space

2.5.11 The Commission noted that the twelfth session of Consultative Meetings on High-level Policy on Satellite Matters (CM-12) and the sixty-sixth session of the Executive Council (EC-66) had discussed the progress of the Architecture for Climate Monitoring from Space. The Architecture was a contribution to the GFCS observation and monitoring component, and to the WIGOS implementation plan, which relied on effective collaboration among space agencies through CEOS, CGMS and WMO. In this regard, it encouraged the WMO Space Programme to work with GCOS and the GFCS office on consolidating user requirements for space-based climate products and services in identifying user cases from GFCS priority areas. While noting that the joint CEOS/CGMS Working Group was focusing on the inventory of Essential Climate Variables, the Commission recommended that the WMO Space Programme provides a report to the Seventeenth Congress on the status of the Architecture from an end-to-end perspective.

User support

User preparedness for new generation of geostationary satellites

2.5.12 The Commission noted the imminent launch of the new generation Himawari-8 by JMA, and the upcoming launches of other new generation geostationary satellites by CMA, EUMETSAT, KMA, NOAA and ROSHYDROMET in the 2015–2020 time frame. Noting the considerable enhancement of capabilities that would be brought by these systems, as well as the risk of disruption for unprepared users, it recalled the Guidelines for Ensuring User Readiness for New-Generation Satellites adopted by CBS-15 and stressed the need for all concerned NMHSs to set up user preparation projects in advance of these launches in order to initiate preparation in a proactive manner. The Commission welcomed the Satellite User Readiness Navigator (SATURN) online portal (http://www.wmo-sat.info/satellite-user-readiness/), which provided users with a unique entry point to information on these new satellite systems. It urged the satellite operators to provide regular and timely updates to SATURN. The Commission therefore adopted Recommendation 14 (CBS-Ext.(2014)) – Preparation for new satellite systems, and requested the Secretary-General to submit it to the seventeenth Congress.

Strategy for improved availability and accessibility of satellite products

2.5.13 The Commission was pleased to note that a draft strategy for improved availability and accessibility of satellite products had been presented to CGMS, as outlined in Annex VII to the present report. It recommended refining this strategy in consultation with ET-SAT, ET-SUP, and OPAG ISS with a view to submit it to the sixteenth session of CBS. In particular, it welcomed the steps taken to develop the Direct Readout Acquisition and Relay of Satellite Data (DRARS) which would follow and enhance the Regional ATOVS Retransmission Services (RARS), and recommended completion of a Guide on DRARS as part of the WIS reference documentation.

2.5.14 The Commission reiterated the importance of establishing standing mechanisms for maintaining user requirements for satellite data and products access and exchange in all WMO Regions as per Resolution 12 (EC-65). The Commission stressed that such mechanisms should engage users from NMHSs and other operational institutions. These mechanisms ensure coordination of users and dialogue with satellite operators, and they should be part of the WIGOS-related component of each regional association working structure.

Information and training

2.5.15 The Commission noted the success of the recent EUMETSAT User Forum in Africa, held in Johannesburg, South Africa, and encouraged the participation of interested Members in the 2014 EUMETSAT Meteorological Satellite Conference in Geneva, Switzerland, the fifth Asia-Oceania Meteorological Satellite Users' Conference (AOMSUC) that was planned in Shanghai, China from 19 to 21 November 2014 (http://www.nsmc.cma.gov.cn/aomsuc5/), and the NOAA Satellite Conference to be held from 27 April to 1 May 2015 in Greenbelt, Maryland, United States. The theme of the NOAA conference was, "Preparing for the Future of Environmental Satellites." A strong focus of the conference would be what users will need to do in order to receive and use data from the new generation of satellites. More information about the conference could be found at: http://satelliteconferences.noaa.gov/2015. Such regional conferences were an excellent forum to enhance collaborative efforts in the utilization of satellite data and products for improved weather and climate services.

2.5.16 The Commission expressed its appreciation to all parties involved in the Virtual Laboratory for Training and Education in Satellite Meteorology (VLab) for the outstanding training activities conducted through the VLab network. The Commission acknowledged CMA's plan to conduct a training workshop on satellite data application from 17 to 18 November 2014, where the experts from NOAA, JMA, KMA and CMA would be invited to offer training to meteorological satellite users from Asia and Oceania through the VLab. It confirmed the nomination of Prof Grigory Chichasov (ROSHYDROMET) as new VLab co-chairperson together with the current co-chairperson Ms Kathy-Ann Caesar (CIMH). It also acknowledged additional training efforts, in particular those conducted in partnership with the Committee on Space Research (COSPAR).

Space weather

2.5.17 The Commission appreciated the progress made by the Inter-Programme Coordination Team on Space Weather (ICTSW) in particular as concerns the definition of space weather services to aviation, in support of the conjoint ICAO Meteorology (MET) Divisional Meeting and CAeM-15 held in Montreal in July 2014. The Commission noted that the Council had requested the ICTSW to develop a detailed four-year plan of activities taking into account the evolving service-oriented nature of space weather services, in consultation and coordination with CAeM and inform the EC WG on SOP so that plans, activities, and supporting expert groups, are consistent with wider WMO and ICAO efforts. In this regard, the Commission recommended that a first version of this plan be submitted to the CBS Management Group for consideration in 2015.

Socio-economic benefits

2.5.18 The Commission also noted that CM-12 had discussed the socio-economic benefits of satellite programmes. It was also pointed out that one aspect of the benefit was the dramatic

reduction (or avoidance) of cost to the society in disaster situations. As WMO Members and their space agencies had to manage priorities in an increasingly resource-constrained environment, it was highly important to evaluate and document these socio-economic benefits in order to assist the decision process on new satellite programmes. In particular, socio-economic benefit assessments should provide an objective basis to inform the transition of mature Research and Development capabilities to an operational status, and to secure sufficient resources to support the development of applications. Recalling the highly successful series of WMO Impact Workshops (e.g. Sedona 2012), the Commission encouraged broadening the assessment of the impact of observing systems on user applications beyond numerical weather prediction.

2.6 Managing changes to Technical Regulations (agenda item 2.6)

Procedures for maintaining Manuals and Guides managed by the Commission

2.6.1 The Commission noted that the procedures for managing WMO-No. 306, the Manual on Codes that were introduced by CBS-XIV had achieved the objective of reducing the time needed to introduce operational changes. It appreciated that CBS sessions could now limit their discussions to contentious proposals, and this had contributed to the ability of CBS to reduce the days worked at CBS-15 by three days compared with CBS-XIV. The Commission identified that the same approach was applicable to all the Manuals and Guides managed by the Commission, and adopted Recommendation 15 (CBS-Ext.(2014)) – Procedures for maintaining Manuals and Guides managed by the Commission for Basic Systems.

2.6.2 The Commission requested its OPAGs to ensure that focal points are in place for each Manual and Guide that will be subject to the simple ("fast track") procedure.

3. CONSIDERATION AND DECISIONS BASED ON THE IMPLEMENTATION OF WMO PRIORITIES FOR 2012–2015 (agenda item 3)

3.1 WMO Integrated Global Observing System (agenda item 3.1)

Decisions and technical regulations supporting WIGOS

3.1.1 The Commission noted the progress achieved in the development of the WIGOS in accordance with Resolution 10 (EC-64); it appreciated the accomplishments and contributions by the CBS experts involved in this, and thanked them for their work, effort and time.

3.1.2 The Commission specifically expressed its appreciation to the Chairperson of the OPAG-IOS, Dr Jochen Dibbern and his Co-Chairperson, Dr Anthony Rea for their comprehensive report on the performance, effective leadership and contribution to further development of the Global Observing Systems. The Commission recognized the substantial work accomplished by OPAG-IOS since CBS-15 in 2012 under their effective leadership. The Commission also thanked Dr Lars Peter Riishojgaard, the previous Chairperson of OPAG-IOS, for his contribution.

3.1.3 The Commission was highly appreciative of the development of the WIGOS regulatory material by the Intercommission Coordination Group on WIGOS (ICG-WIGOS) Task Team on WIGOS Regulatory Material. It adopted Recommendation 16 (CBS-Ext.(2014)) – Regulatory material of the WMO Integrated Global Observing System, and requested the Secretary-General to make the necessary arrangements for its submission to the Seventeenth World Meteorological Congress.

3.1.4 The Commission noted the decision of the Executive Council at its sixty-sixth session (EC-66) that the 2016–2019 financial period was to be designated the WIGOS Pre-Operational Phase. CBS further endorsed the notion of shifting the focus for the next financial period toward regional and national activities, along with further development of Regulatory Material and supplementary guidance, full implementation of metadata standards and Quality Management. The Commission requested OPAG-IOS to work with ICG-WIGOS and other relevant bodies to develop

a plan for the WIGOS Pre-operational Phase, to be submitted to the Seventeenth World Meteorological Congress for approval.

3.1.5 The Commission noted that delivery of the full benefits of WIGOS would depend on the use of observations from networks external to NMHSs including freely shared data and, potentially, commercial data and contributed data with constraints on free and open exchange. It agreed that it would be helpful to Members to have consistent guidelines and best practices on how to address these types of data within the WIGOS framework. The Commission was informed that ICG-WIGOS would be considering these issues and the associated data policy and technical considerations, and agreed that its OPAG-IOS and OPAG-ISS would contribute as required to this activity. ICG-WIGOS would provide a preliminary report on this matter to the Seventeenth World Meteorological Congress and continue the work as matter of priority in the WIGOS Pre-operational Phase.

3.1.6 The Commission appreciated the progress made in the development of the WIGOS Information Resource (WIR), and noted that the Observing System Capability Analysis and Review Tool (OSCAR) in particular had gained substantial attention and visibility among the WMO Members. The Commission was informed of the proposal to migrate the operational hosting of OSCAR from the WMO Secretariat to MeteoSwiss and assigned the responsibility within CBS for overseeing and reviewing of OSCAR as explained in Annex VIII to the present report.

3.1.7 The Commission further decided that during the development phase, the technical specification of OSCAR should be coordinated by the Inter-Programme Expert Team on the WIGOS Framework Implementation Matters (IPET-WIFI) in close collaboration with the Secretariat; it approved the revised Terms of Reference of IPET-WIFI as given in Annex IX to the present report. The Commission decided to establish an additional IPET-WIFI Sub-Group on OSCAR Development (SG-OD) and requested its Management Group to identify relevant experts to support this work.

3.1.8 The Commission welcomed the steps taken to monitor the actions listed in the *Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP)* and requested the Inter-Programme Expert Team on the Observing Systems Design and Evolution (IPET-OSDE) to actively support and monitor the implementation process through agents nominated to lead each Action in the EGOS-IP, with input from a network of national focal points.

3.1.9 The Commission noted the request of EC-66 for CBS to take the lead in developing a *Vision for WIGOS in 2040*, which would include a “Vision for the WIGOS component observing systems in 2040”, with involvement of the other technical commissions and requested OPAG-IOS to take steps to start develop such a document, with a view toward submission to the Eighteenth World Meteorological Congress (Cg-18) in 2019.

3.1.10 The Commission noted with appreciation the development of the WIGOS Metadata Standard by the ICG-WIGOS Task Team on WIGOS Metadata (TT-WMD), the latest version of which is reproduced in Annex X to the present report. It requested the OPAG-ISS Inter-Programme Expert Team on Metadata and Data Representation Development (IPET-MDRD) to work on the technical aspects of the implementation of the WIGOS Metadata Standard for the metadata exchange, in close cooperation with TT-WMD and the CCl Expert Team on Climate Data Management Systems (ET-CDMS). The Commission requested its Management Group to ensure that sufficient resources are available for this important task.

3.1.11 The Commission noted the request from EC-66 that further guidance be provided to Members regarding WIGOS Data Management (DM), in particular on issues such as storage and archival methods, reprocessing, discoverability and data access. It requested OPAG-IOS and OPAG-ISS to work together to develop a concept paper on WIGOS DM, in close collaboration with all relevant technical commissions, and especially with CCl.

3.1.12 The Commission noted that all stations, platforms and instruments contributing to WIGOS would need identifiers in order for them to be properly referenced in the observational data records themselves, in the associated WIGOS metadata, and for the purpose of managing and

planning the networks. The Commission stressed that providing identifiers for any observing station or platform known to Members, regardless of the commitment of the operator regarding data quality or sustained operation, was essential for WIGOS. Potential issues regarding data quality and sustainability would be documented in the associated WIGOS metadata records. The Commission noted the structure for WIGOS identifiers provided in Annex XI to the present report and recommended that this structure be included in the Manual on WIGOS.

Regional Basic Synoptic Network (RBSN) and Regional Basic Climatological Network (RBCN)

3.1.13 The Commission noted the results of the RBSN and RBCN performance monitoring, and welcomed an increase in the implementation of the surface-based subsystem of the GOS. It also noted that globally there is an increase of around 10% in the number if RBSN stations, continuing the positive trend witnessed during the previous intersessional period. The Commission encouraged Members to follow the WMO guidance material when implementing automatic weather station (AWS) networks, as provided in the *Guide to the GOS*, *EGOS-IP*, *the CIMO Guide*, IMO reports and other relevant WMO guides, as well as the guidance to be made available in the *Guide to WIGOS*.

3.1.14 The Commission, noting that a substantial number of stations were not recorded in the WWW monitoring statistics due to the fact that they were not reporting to the main synoptic hours, requested OPAG-IOS and OPAG-ISS to review the reporting requirements, in particular for the upper-air stations of the RBSN.

3.1.15 The Commission noted that the global increase of climatological stations reporting CLIMAT by 5% since 2014, to a level of 89% in 2014, was in part due to the CBS Lead Centres for GCOS agreeing to expand their monthly monitoring to all CLIMAT messages of the RBCN. The Commission requested the CBS Lead Centres for GCOS to distribute the extended monitoring results to Members, noting that GSN stations remain the monitoring priority.

3.1.16 The Commission endorsed the following GCOS recommendations:

(a) Members should formally report to WMO and GCOS at the earliest opportunity on station closures or changes in practice which have an impact on the GSN and GUAN;

(b) Members should make every effort to ensure that the minimum requirements, i.e., reporting temperature and wind to at least a level of 30hPa, and humidity to the tropopause, on at least 25 days each month, are met by all GUAN stations.

Status of surface-based component of the GOS in the Regions

3.1.17 The Commission endorsed the recommendations of the Implementation and Coordination Team on Integrated Observing Systems (ICT-IOS) regarding the implementation of observing systems in the Regions as provided in Annex XII to the present report.

Aircraft-based observations

3.1.18 The Commission noted with appreciation the work of the Expert Team on Aircraft-Based Observing Systems (ET-ABO) in assisting CIMO with finalizing the AMDAR Onboard Software Functional Requirements Specification and in the development of several reports and guidance documents related to AMDAR including: “AMDAR Coverage and Targeting for Future Airline Recruitment”, “The Benefits of AMDAR to Meteorology and Aviation” (WIGOS Technical Report 2014-1) and “Requirements for the Implementation and Operation of an AMDAR Programme” (WIGOS Technical Report 2014-2). The Commission recommended that these documents be in the WIGOS Regulatory and Guidance Material, or referred to where appropriate.

3.1.19 The Commission was informed of the development of the Aircraft-Based Observations Programme (ABOP) Strategy and Implementation Plans, in line with relevant actions of the

EGOS-IP. The Strategy proposes a regional approach to the development and enhancement of aircraft-based observations and the AMDAR observing system in collaboration with, and under the leadership of, the WMO Regional Associations. The Commission endorsed the proposed approach and adopted Recommendation 17 (CBS-Ext.(2014)) – Enhancement and expansion of aircraft-based observations.

Surface-based remote sensing observations

3.1.20 The Commission, considering the outcome of the Workshop on the Regional and Global Exchange of Weather Radar Data hosted by the Met Office in the UK in April 2013, appreciated that a newly established CBS OPAG-IOS Task Team on Weather Radar Data Exchange would develop a global standard for representing weather radar data in support of regional and global exchange of weather radar data. The Commission noted the importance of this work, which would be vital in maximizing the contribution of Weather Radars to the widest possible set of application areas.

3.1.21 The Commission noted with appreciation the survey of a wind profiling radar conducted by OPAG-IOS and the outcome, published as “Evaluation of WMO CBS Wind Profiler Survey” (WIGOS Technical Report 2014-3). The Commission encouraged Members to use this guidance to help maximize their benefits from this important observing technology.

Marine meteorological and oceanographic observations

3.1.22 The Commission noted with concern that the completion of the initial composite ocean observing system had not progressed substantially in the last few years, and remained at a level of about 62%. It requested its Members to contribute to the JCOMM Observations Programme Area Implementation Goals and to sustain the marine meteorological and oceanographic observing system as a top priority. In particular, efforts should be made to fund and install barometers on newly deployed drifters, and to improve the tropical moored buoy array data availability through enhanced partnership. Accordingly the Commission adopted Recommendation 18 (CBS-Ext.(2014)) – Support of Members to the implementation of the marine meteorological and oceanographic observing system in support of numerical weather prediction.

CryoNet of the Global Cryosphere Watch (GCW)

3.1.23 The Commission, noting the progress on the development of the Global Cryosphere Watch (GCW), requested that priority be given to the development of the core GCW surface-based observing network, CryoNet, which was a component of WIGOS.

3.1.24 The Commission recognized that there was a need for wider exchange of the in-situ snow depth data from SYNOP measurements. Noting the effort done in collaboration with OPAG-ISS and ECMWF toward the development of a new BUFR template, which would allow Members to report snow and no snow conditions, CBS requested OPAG-ISS to use the fast-track procedure for implementation of this new BUFR Template.

Evolution of global observing systems

3.1.25 The Commission expressed its satisfaction with the fact that the new Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP) was now available in English, French, Spanish and Russian, and requested that Members regularly report to the Secretariat regarding progress on the actions listed in EGOS-IP. It urged those Members who had not yet nominated their National Focal Point for this activity to do so by the end of December 2014.

3.1.26 The Commission requested OPAG-IOS to monitor and actively promote progress made by Members and other implementing agents on the actions listed in the EGOS-IP, and to find ways of improving the engagement of Members and Regions in completing these actions. It encouraged Members to mobilize resources to drive these activities forward.

3.1.27 The Commission appreciated the work of the Inter-Programme Expert Team on Observing System Design and Evolution (IPET-OSDE) on Observing System Network Design (OSND) principles and guidance. It recommended that these principles, listed in Annex XIII to the present report, be included in the first edition of the Manual on WIGOS.

Observing System Experiments (OSEs) and Observing System Simulation Experiments (OSSEs)

3.1.28 The Commission noted with appreciation the good progress made regarding impact studies, and recommended enhanced contributions of Members to continue with the development and research of adjoint-based observation impact assessment tools as a complement to traditional OSEs, to undertake OSEs for the optimization of regional composite networks, and to conduct OSEs and OSSEs to address the specific science questions listed in Annex XIV to the present report.

3.1.29 Noting the growing visibility of the WMO Impact Workshops, the last of which took place in Sedona 2012, and recalling the guidance from EC-66 that the model for impact assessment employed by these highly successful Workshops be broadened to include additional application areas, the Commission requested its Management Group to initiate preparations for a Sixth WMO Impact Workshop, tentatively to be convened during the first half of 2016. The Commission further noted with appreciation the offers extended by China and Germany to host this event, and – considering that four of the five previous Workshops had been held in Region VI – decided to accept China's invitation to host the next Workshop, and that holding the event in Germany be considered a back-up solution.

3.1.30 The Commission recognized the availability of various tools to perform impact studies on a relatively cost-effective basis; it encouraged observing programmes managers/operators to propose specific questions regarding the impacts of observations on NWP through IPET-OSDE.

Centennial Observing Stations

3.1.31 The Commission recalled the importance of long-term series of observations as a fundamental reference for a variety of meteorological and environmental applications, particularly for monitoring climate variability and for doing research in and providing services related to climate change. It further recalled that the Executive Council at its sixty-fifth session had requested CCl to investigate, jointly with CIMO and GCOS, existing site certification mechanisms, network criteria and monitoring principles and to set up an appropriate WMO mechanism for the recognition of centennial observing stations, based on a minimum set of objective assessment criteria to be used by Members in order to protect these critical stations from future closure or deteriorating conditions. The Commission, noting the progress made in defining such a mechanism, agreed to contribute to its further development.

Reporting of Wind

3.1.32 The Commission noted the discussion at CIMO-16 (*Abridged Final Report with Resolutions and Recommendations of the Sixteenth Session of the Commission for Instruments and Methods of Observation* (WMO-No. 1138), paragraphs 4.38–4.4.1) in regard to the reporting of wind and agreed to work with CIMO and other technical commissions, where appropriate, to consider changes to the *Guide to Instruments and Methods of Observation* (WMO-No. 8, the CIMO Guide) and/or other relevant WMO regulatory material, to address issues identified on:

(a) Reported resolution of wind direction and required measurement uncertainty;

(b) Reporting of wind data from stations with multiple anemometers; and

(c) Wind reporting from oil rigs and ships.

Collaboration with CIMO on Radio-Frequency Protection

3.1.33 The Commission noted the recent reappointment of CIMO Theme Leaders on Radio-Frequency Protection and urged SG-RFC to continue to liaise with them on relevant radiofrequency matters.

WIGOS Demonstration Project on Volcanic Ash Detection

3.1.34 The Commission acknowledged the view expressed at CIMO-16 that improved detection of volcanic ash will require collaboration between different WMO constituent bodies. The Commission agreed to work with CIMO, CAS, CAeM, RA VI, and in particular EUMETNET and EARLINET on the development of a possible RA VI WIGOS volcanic ash demonstration project.

WMO Centennial Stations

3.1.35 The Commission was informed of the recommendation of CIMO-16 to support the CCl initiative on recognition of Centennial Stations, including finalization of the designation criteria, the establishment of a suitable mechanism for the recognition of centennial stations and sustaining the designated stations.

New Edition of the* Guide to Meteorological Instruments and Methods of Observation *(WMO-No. 8), CIMO Guide

3.1.36 The Commission was informed of the approval by CIMO-16 of a new, extensively revised edition of the CIMO Guide, which, notably contains a new part (Part III) on Space-Based Observations. The new version of the CIMO Guide is available on the WMO website at http://www.wmo.int/pages/prog/www/IMOP/IMOP-home.html.

3.1.37 The Commission noted in particular the updated information in the CIMO Guide on the need to phase out the use of instruments containing mercury in order to comply with the UNEP Minamata Convention on Mercury (http://www.mercuryconvention.org/). This would come into force in 2020, banning the manufacture, import and export of products containing mercury, with significant consequences for Members still using these types of instruments. The Commission also noted the new European Union regulation that totally banned sales of these products in Europe as of April 2014. The Commission urged all Members which still employed instruments containing mercury to develop transition plans to replace these instruments with other alternatives to ensure the continuity and quality of their observations, noting that appropriate mercury-free alternatives were generally available and affordable. The Commission urged its Members to consult the new edition of the CIMO Guide for further information on this.

***Revision of the* International Cloud Atlas**

3.1.38 The Commission expressed its appreciation that CIMO proposed to carry out an extensive revision and update of the *International Cloud Atlas – Manual on the Observation of Clouds* (WMO-No. 407, Volumes I and II, the ICA), parts of which constituted Annexes to WMO *Technical Regulations* (WMO-No. 49). This would make the ICA the undisputable web-based global reference standard for the classification and reporting of clouds and meteors. The Commission noted that funding had to be identified for this activity as the document had not been updated since 1975 (Volume I) and 1987 (Volume II) and no technical commission had been in charge of this document until recently. The Commission acknowledged the importance of this proposal in view of the ICA's importance to many Members, in particular the developing countries which still made extensive use of manual observations.

3.2 **WMO Information System** (agenda item 3.2)

Progress with implementing the WMO Information System

WIS Core Network

3.2.1 The Commission noted the successful migration of the Regional Meteorological Data Communications Network (RMDCN) and WIS Core Network to the next generation RMDCN (RMDCN NG). It expressed its appreciation to ECMWF for managing the migration and for continuing its support of this important component of WIS. It noted however, that the Global Information System Centre (GISC) Brasilia and GISC Islamic Republic of Iran were still not connected to the WIS Core Network. In particular, the supplier of the RMDCN NG was unable to obtain an export licence for installing the RMDCN NG at GISC Tehran for reasons that are beyond the ability of CBS to influence. Noting the importance of a fully connected WIS Core Network for the free and unrestricted exchange of information to all National Meteorological and Hydrological Services (NMHSs) basic services, the Commission adopted Recommendation 19 (CBS-Ext.(2014)) – Critical role of WMO Information System networks.

3.2.2 The Commission requested ICT-ISS, in collaboration with GISC Tehran, to assist the supplier in the design and implementation of an affordable, interim solution to allow the Islamic Republic of Iran to connect to the WIS Core Network as fully as possible.

3.2.3 The Commission noted the progress with piloting IPv6. It noted that the requirement for IPv6 will most likely be driven by Members' user communities rather than to support information exchange between NMHSs. It encouraged Members with the appropriate capability to participate in the IPv6 Pilot.

3.2.4 The Commission noted Members' concern that the present full exchange of all data between all GISCs may not be scalable. It noted that current work has revealed that multicast was not a viable solution at this time, although it encouraged those centres with a need for multicast on fixed networks to continue with their investigations. It also noted the proposed pilot by some centres to trial cloud-based solutions for GISC to GISC exchange and highlighted that any pilot should consider potential national policy issues on use of cloud-based solutions.

WIS Centres

3.2.5 The Commission reviewed the progress in the identification of WIS centres noting that 363 centres had been registered. These included 223 National Centres (NCs), 125 (Data Collection or Production Centres (DCPCs) and 15 GISCs. It noted that 14 of the 15 GISCs had been successfully audited by CBS and were either operational or in the process of becoming operational. GISC Casablanca was scheduled to be audited before the end of 2014. The Commission noted for DCPCs and GISCs, only those centres that had demonstrated to CBS their compliance with the standards described in the *Manual on the WMO Information System* could be entered into the Manual as registered WIS centres. It noted that the current status of WIS centre identification and certification by CBS was available online for individual countries or graphically on the WMO Country Profile Database (https://www.wmo.int/cpdb/ or for graphical representation directly, https://www.wmo.int/cpdb/pages/map/regions/wiscentres) or on the WIS web pages (Status on WIS centre certification by CBS – http://www.wmo.int/pages/prog/www/WIS/centres/). The Commission expressed its appreciation to those centres that had committed to contribute through WIS and encouraged those centres that had not yet done so, to complete the demonstration process so they could be recorded in WMO-No. 1060 – *Manual on the WMO Information System*.

3.2.6 The Commission emphasized the importance of centres maintaining their compliance with the agreed standards and practices for ensuring the ongoing functionality of WIS. It stated that the review should occur at least once every eight years for all centres, with half interval reviews for GISCs. It thanked the experts in the Expert Team on WMO Information System Centres' Task Team on WIS Centre Audit and Certification (ET-WISC/TT-CAC) for their efforts and support to

centres in demonstrating their WIS functionality to CBS and highlighted that such expertise will continue to be needed in the certification of WIS compliance in new centres and for the periodic assessment of compliance in existing centres.

3.2.7 The Commission highlighted the importance of regional oversight of the implementation of WIS and was pleased that Regions II, V and VI had WIS implementation plans (WIS IP) in place and that Regions I and III were to consider their WIS IP at the upcoming sessions this year. It noted with satisfaction that all regional WIS IP include the need to monitor WIS implementation.

3.2.8 The Commission noted that effective technical solutions for the implementation of WIS functionality had been achieved through upgrading a Member's current information management and message switching systems or by making use of the remote WIS services offered at the GISCs based on Internet connectivity. It thanked the industry through the Hydro-Meteorological Equipment Industry (HMEI) and the OpenWIS consortium for making this possible. It noted that regardless of which technical solution was used, the principal component of WIS implementation lay with the capacity development of staff to enable them to create and manage discovery metadata. It recognized the importance of including capacity development in Regional WIS IPs and of ensuring all NCs had sufficient expertise in WIS through regional monitoring of national progress and taking targeted actions to assist those NMHSs that were lagging in the required competencies.

3.2.9 The Commission emphasized the critical role of GISCs in capacity development and, noting many GISCs had already undertaken initial training for their users, emphasized the need to provide further training. It also identified the need to establish WIS specific online training modules that will assist in local training and in maintenance of the required WIS competencies. It invited Regional Training Centres to work with GISCs and HMEI to address this important need.

Clarifying operating practices for the WMO Information System

3.2.10 The Commission noted the collaboration mechanisms being established by the GISCs to create a multilateral decision process for making operational decisions. It noted that some decisions, such as prioritizing of data streams across the WIS Core Network, or making data or product streams available or not in the cache, might extend beyond in the scope of GISCs decision making authority. The Commission adopted Resolution 2 (CBS-Ext.(2014)) – Establishment of an Intercommission Task Team to Review Processes for Prioritizing of Data Streams and Cache Content.

3.2.11 The Commission noted that the reference technical specifications for WIS and the WIS Functional Architecture were stable and should be reflected in the WIS Manuals and Guides. Similarly, the Use Cases associated with the TechSpecs and the Test Cases associated with demonstrating compliance should also be reflected in WMO-No. 1061 – Guide to the WIS.

3.2.12 The Commission noted that in addition to the agreed practices and procedures recommended for inclusion in the WIS Manual and Guide, WIS centres were developing online guides in order to assist other WIS centres in establishing and maintaining WIS functionality. It encouraged expert teams to continue this development making use of the Web for ease of access and maintenance, and to migrate practices that are likely to be long term and stable into numbered WMO publications or the WIS Manual and Guide as appropriate.

WIS Monitoring

3.2.13 Monitoring was a key component of the WIS that contributes to managing day-to-day operations, long-term planning and identification and resolution of problems. The Commission welcomed the interim guidance on WIS monitoring (at http://wis.wmo.int/wis-monitor) that specifies near-real time and quarterly monitoring practices, and encouraged the Implementation Coordination Team on Information Systems and Services (ICT-ISS) to proceed with a pilot implementation with volunteer GISCs so that the interim guidance can be tested and updated with the aim of producing a standard practice for inclusion in WMO-No. 1061 – *Guide to the WMO Information System* at CBS-16.

3.2.14 WIS monitoring would concentrate on the effectiveness of flow of information between centres. It would concentrate on the exchange of packages containing information, such as the bulletins that currently circulate on the Global Telecommunications System, rather than on the contents of those bulletins. Numerical Weather Prediction centres, for example, were better placed than telecommunications centres at recording which observations were available and the quality of those observations. The Commission asked each of its Open Programme Area Groups (OPAGs) to consider how their regional and global centres could contribute to monitoring the quantity and quality of information exchanged by the programmes to which the centres contribute, so that this could be used to complement the monitoring information gathered by the WIS. The Commission also recognized that gathering monitoring information was not sufficient to ensure improvements in quality or quantity of information being exchanged, and it asked OPAG-ISS to recommend a process for collating the information from the different monitoring systems and providing feedback to information providers and the operators of WIS centres.

Registering of WMO Technical Regulations and information resources in WIS

3.2.15 A significant omission from the WIS metadata catalogue is that it did not include entries for the WMO Manuals, Guides or other information services that the WMO Secretariat provides to support Members. To allow such metadata to be published, the Commission endorsed the WMO Secretariat as a Data Collection or Production Centre with GISC Toulouse as its principal GISC.

Cooperation with OGC

3.2.16 Standards for web services offer the potential to simplify how information from different sources could be combined, but without guidance on best practice suppliers were likely to make different, incompatible choices in how they present their information. WMO's agreement with the Open Geospatial Consortium (OGC) had resulted in several WMO experts participating in OGC domain working groups that were seeking to provide guidance on best practice. The Commission asked OPAG-ISS to nominate a rapporteur to report on and coordinate the activities of these experts.

Cooperation with CAeM

3.2.17 At the Conjoint CAeM/ICAO Meteorology Divisional Meeting in July 2014 it was decided that meteorological information would form a critical component of the System-Wide Information Management (SWIM) environment that was being planned by ICAO that was the planned future for the Air Traffic Management system. SWIM was expected to use technologies such as web services. Given that many Members were also responsible for providing information for international civil aviation, it was important that WIS and SWIM are interoperable to reduce costs and complexity for Members. The Commission asked OPAG-ISS to coordinate its work with the CAeM Expert Team on Information and Services for Aviation.

WIS Discovery Metadata

3.2.18 The Commission noted that four changes had been implemented to the WMO Core Metadata Profile of ISO 19115 using the fast track procedure. It further noted that the International Organization for Standardization (ISO) had issued a new version of the standard for geographic metadata (ISO 19115-1:2014) and that the WMO Core Profile was not compliant with this new standard, but that ISO had not yet completed the specifications for the associated representation of this standard in extensible markup language (XML). The Commission agreed that the Inter-Programme Expert Team on Metadata and Data Representation Development (IPET-MDRD) should provide an updated specification of the WMO Core Metadata Profile (version 2) that was compliant with both ISO 19115-1 and 19115-2 (extensions for imagery and gridded data) following publication by ISO of the XML representation of ISO 19115-1:2014. The ISO publication was expected mid-2016, too late for the new WMO Core Metadata Profile to be approved by the CBS-16 session. The Commission noted that as a consequence the Commission may need to approve WMO Core Metadata Profile version 2 by correspondence.

3.2.19 The Commission welcomed the draft *Guidance on WIS Discovery Metadata* (http://wis.wmo.int/page=IndexForMetadataGuidance) and stressed the importance of providing this information in languages other than English. The Commission also noted that the guidance may need to be updated whenever a change to the WMO Core Metadata Profile was implemented and that development of further guidance was still needed. The Commission therefore asked OPAG-ISS to introduce a formal Guide to WIS Discovery Metadata at its sixteenth session, and to make sure that the definition of WMO Core Metadata Profile version 2 was accompanied by an update to that Guide. It asked OPAG-ISS to maintain web-based guidance in the interim.

3.2.20 The Commission noted that Members might have national or regional obligations to provide discovery metadata compliant with standards other than the WMO Core Metadata Profile and that maintaining separate metadata records to comply with different standards is inefficient and prone to error. It therefore recommended that Members in this situation work with IPET-MDRD to create appropriate guidance, practices or recommendations for changes to the WMO Core Metadata Profile.

3.2.21 The Commission noted that the development of XML representations of information in support of international civil aviation had introduced a “codes register” (http://codes.wmo.int) to provide web-based definitions of the entries in code tables and thanked the United Kingdom for hosting this service. It asked OPAG-ISS to use the codes register as an additional method of publishing other approved code tables.

3.2.22 The Commission noted that WMO-No. 1060 – *Manual on the WMO Information System* and WMO-No.1061 – *Guide to the WMO Information System* needed to be updated to reflect changes to the structure of Technical Regulations and to clarify items in response to feedback.

Capacity development to support operation of the WMO Information System

3.2.23 The Commission noted with pleasure that a workshop on WIS training had produced both a set of competences needed to support WIS and also recommendations on types of training and learning activity that might help individuals develop the competences. These are listed in Annexes 5 and 6 of Recommendation 21 (CBS-Ext.(2014)). It emphasized that not every individual working with WIS would need all the competences, but that most WIS centres would need access to people able to apply the competences. The competences were specific to WIS, but individuals who were able to demonstrate that they could apply the competences would also need to be competent in generic information technology competences, training for which was widely available through both government and commercial training activities.

3.2.24 The Commission adopted Recommendation 20 (CBS-Ext.(2014)) – Updates to the *Manual on the WMO Information System* (WMO-No. 1060) and Recommendation 21 (CBS-Ext.(2014)) – Updates to the *Guide to the WMO Information System* (WMO-No. 1061).

Future development of the WIS

3.2.25 The Commission recognized the importance of creating and delivering a long-term vision for the evolution of the WIS. It tasked ICT-ISS to create and maintain a strategy for the development of the WIS, and added an item to the Terms of Reference of ICT-ISS as in Annex XV to the present report.

Data Management Supporting Climate

Climate Data Management System specifications

3.2.26 The Commission took note of the work being done by the Commission for Climatology on guiding the development of Climate Data Management Systems (CDMSs) as integrated computer-based systems that facilitate the effective archival, management, analysis, delivery and utilization of a wide range of integrated climate data. CDMSs help National Meteorological and Hydrological Services (NMHS) to organize and undertake basic climatological functions and

services based on real time or delayed mode data ingestion, quality control, permanent data archiving, and data and metadata management in addition to the generation of climatological products, such as averages, frequencies, extremes and other tailored products to meet user needs. Furthermore, CDMSs facilitate the provision of standard datasets that contribute to the World Climate Programme such as CLIMAT reports, World Weather Records, and Climatological Standard Normals.

3.2.27 The Commission welcomed the approach taken by CCl to develop a technical reference publication on the specifications of CDMSs as a mechanism to guide the NMHSs and other users for aligning CDMSs with the current and evolving user requirements, technological advances and WMO practices, taking into account the varying observation networks, and other data sources. The Commission welcomed the Recommendation made by CCl-16 that the Commission works closely with CCl in order to identify the relevant parts of the CDMS specifications publication for possible inclusion in the WMO Technical Regulations. It adopted Resolution 3 (CBS-Ext.(2014)) – Regulation of Climate Data Management System specifications through the WMO Information System.

High Quality Global Data Management Framework for Climate

3.2.28 The Commission was informed on the CCl led inter-programme initiative to work towards the development of a High Quality Global Data Management Framework for Climate (HQ-GDMFC) aiming at making use of an extended range of climate data types needed to support GFCS Climate Services Information System (CSIS) on an operational basis. The Framework would provide the opportunity of addressing the existing potential for harmonizing across WMO climate programmes the definitions and processes that deal with data management in support of climate, e.g. data rescue and preservation, archiving and related tools and functions for quality control, calculation of statistics and basic products, homogenization and analyses. In addition, the HQ-GDMFC was expected to contribute to wider cross-commission discussion on data management, under the coordination of CBS, noting the potential to capture the benefits of modern information and remote-sensing technologies and the management of the associated large data volumes, especially in relation to standardized approaches to data archival and management.

3.2.29 The Commission agreed to work closely with CCl and other commissions, within the newly established CCl Inter-Programme Expert Team on Climate Data Modernization Programme (IPET-CDMP) to develop HQ-GDMFC. The Commission considered its involvement in this initiative as a contribution to building an essential element of a broader WMO data management framework. It further stressed that there is a potential to benefit from using the existing CBS data infrastructure such as GDPFS, WIS and WIGOS to deliver such a HQ-GDMFC.

World Weather Records (WWRs)

3.2.30 The Commission was informed on the successful implementation the new approach for the annual submission of the World Weather Records through the CBS lead centres and the World Data Centre for Meteorology-NOAA NCDC. The CBS Lead Centres of Australia, Germany, Morocco and Japan and the WDC/NOAA-NCDC were very active in collecting the WWRs. The Commission further stressed the importance of providing these data sets as decided by EC-64 following the new approach by which the annual WWR of year Y should be submitted as soon as possible during the next year but not later than June of Y+1. This would allow a timely compilation of WWRs globally and therefore allow better use in the WMO Climate System Monitoring.

Climatological Standard Normals

3.2.31 The Commission was pleased to note that CCl adopted a recommendation for amending WMO-No. 49 *Technical Regulations*, Volume I: *General Meteorological Standards and Recommended Practices*. The recommendation stipulates that the Climatological Standard Normals shall be calculated every ten years at the start of every new decade having year digit 1; and apply to the most recent 30 year period, with 1981–2010 being the new current standard; and that for the specific purpose of long-term climate change monitoring, the period 1961–1990 shall

be retained as a reference period in perpetuity, or until such time as a compelling scientific case to change it arises.

3.2.32 The Commission further noted with appreciation CCl's intention to initiate and monitor a review of existing WMO documents that refer to computing normals, such as WMO/TD-No. 341 (1989) on Calculation of Monthly and Annual 30-Year Standard Normals; WMO-No. 306 (2012) Manual on Codes; WMO-No. 847 (1996); WMO-TP-108 (1967); WCDMP-61 (2007), etc. in order to ensure full consistency with the new approach.

3.2.33 The Commission agreed to collaborate with CCl on this important work to ensure consistent guidance across the relevant regulatory material under CBS mandate.

Designation of Climate-relevant WIS-DCPCs

3.2.34 The Commission noted with appreciation the CCl plan to develop a list of general criteria as a basis for CCl's views on the candidacy of climate-relevant centres to become WIS-DCPCs as required under the Technical Regulations (WMO-No. 49), Volume I, Part I, section 3, paragraph 3.3.3 on the designation of Global Information System Centres (GISCs) and Data Collection or Production Centres (DCPCs) of the WMO Information System (WIS). CCl also agreed to apply, for the time being, a tacit endorsement approach for existing well-defined entities applying to become WIS-DCPCs, such as WMO Regional Climate Centres (RCCs).

3.3 Disaster risk reduction (agenda item 3.3)

Progress with the implementation of CBS contributions to the WMO disaster risk reduction activities and plans for post-2015

3.3.1 The Commission recalled that at its fifteenth session (CBS-15, Jakarta, Indonesia, 2012) it had established a CBS Task Team on the Provision of Operational Meteorological Assistance to Humanitarian Agencies under the joint leadership/responsibility of the OPAGs on DPFS and PWS, and in liaison with other relevant technical commissions and programmes. The Commission noted that, under its Terms of Reference (TORs), this Task Team had to work on several areas which broadly included: the requirements for products and services by Humanitarian Agencies, the development of "Global and Regional Arrangements", and dissemination aspects and therefore recognized the work of this Task Team as a direct and major contribution from CBS to the WMO disaster risk reduction priority.

3.3.2 The Commission noted the requirements for operational meteorological and hydrological products and services by Humanitarian Agencies and stressed that WMO found it difficult to meet these requirements because:

a. WMO was built on the primacy of NMHSs as providers of forecasts – with WMCs, RSMCs, RCCs and GPCs providing forecast guidance. There was no clear agreement in the WMO community on protocols for the provision of global scale guidance directly to users outside the WMO community. Such information was one requirement of the globally-acting HA community (to obtain a timely, broad global picture of meteorological hotspots). Such global-scale guidance may at times differ in detail from regional guidance and NMHS-issued forecasts. Therefore, protocols for providing global-scale guidance to users outside the WMO community needed to be developed (precedents do exist – for example global significant weather forecast charts as issued by World Area Forecast Centres). Weather, climate and hydrology were dealt with separately within WMO (and within most NMHSs). These factors made it difficult to provide services seamlessly across all time scales.

b. The development of a user-engagement culture was still at an early stage within WMO. A framework to enable operational engagement with the Humanitarian Agencies has not been established, nor the necessary resources identified.

c. The points mentioned in a. and b. above, together with a lack of capacity and capability within NMHSs, made it difficult to provide tailored, consistent services to the Humanitarian community.

d. The WMO community had historically been product-centric rather than service-orientated; improvements in service delivery were needed to enable best use of risk-based warnings and impact-based forecasting.

e. While the CBS Task Team, in coordination with other relevant WMO Technical Commissions and programmes, had initiated the process to capture the requirements of the Humanitarian Agencies, there remained a need to establish a mechanism for operational communication;

f. The WMO community typically used meteorologically-specific formats to exchange information rather than standard geo-referenced formats. The metadata needs of the Humanitarian Agency user community had not as yet been defined;

g. The WMO community had not historically seen the training of users as part of its remit;

h. The WMO community tended to verify models and numerical products; user-led verification and validation was not widely practiced within the WMO community;

i. Many NMHSs lacked a legal mandate for their role as authoritative providers of warnings of high impact weather.

3.3.3 The Commission also stressed that the consequences of WMO not responding to user requirements in this context were:

a. Humanitarian Agencies would continue to use non-authoritative sources of meteorological and hydrological information, possibly leading to inconsistencies, confusion and ineffective Humanitarian Agency planning and response;

b. Reputational damage to WMO, its GDPFS centres, including NMHSs, particularly in respect of a perceived inability to effectively address user needs;

c. Reputational damage to the Humanitarian Agencies through incorrect and inappropriate use and interpretation of meteorological information;

d. Without effective leadership by WMO the non-authoritative information sources would proliferate, leading to inefficiencies and duplication of effort;

e. Perceived lack of relevance of the WMO community might lead to a diversion of resources from NMHSs to agencies that were closer to the user.

3.3.4 The Commission recommended the development of an integrated holistic approach (as an authoritative framework) to support humanitarian agencies that took into account (1) the need for capacity development of WMO Members, with respect to humanitarian needs and requirements for support, (2) existing activities or practices among WMO Members that could be expanded to include humanitarian concerns, (3) opportunities for sharing and training on the interpretation of meteorological products, and the potential impacts of meteorological hazards on vulnerable populations, and (4) advocated the use of authoritative information rather than open sources by partner agencies. In this context, and while largely endorsing the activities identified by the Task Team to support the work of the humanitarian agencies (as found in the Task Team meeting report, July 2013), the Commission noted that the WMO Executive Council, at its sixty-sixth session (EC-66, June 2014), had requested CBS to review the governance procedures relating to the provision and availability of information on meteorological, hydrological and other environmental hazards, with a view to developing appropriate guidance for consideration by Cg-17

(2015), and therefore adopted Recommendation 22 (CBS-Ext.(2014)) – Provision of operational meteorological assistance to humanitarian agencies.

3.3.5 Recognizing the fundamental importance of multi-hazard information and services provided by NMHSs in support of risk-informed and impact-based disaster risk reduction decision-making, the Commission acknowledged the CBS contributions in documenting good practices and guidelines to assist the relevant activities of WMO Members, including: (i) WMO hazard definitions and classification, and hazard data/metadata and modelling requirements to support loss and damage data collection and risk analysis in collaboration with the Disaster and Civil Protection Agencies (DCPAs) and other users (e.g. reinsurance, private risk modelling companies); (ii) WMO Guidelines for National Meteorological and Hydrological Services on Institutional Partnerships in Multi-Hazard Early Warning Systems and Supporting Emergency Preparedness, Response, Rescue and Early Recovery Operations; and (iii) WMO Guidelines on Requirements for Meteorological and Climate Services for Disaster Risk Financing and Insurance (completed or forthcoming by 2015). The Commission encouraged its Members to actively participate in (a) the national process for risk analysis, building partnerships and working arrangements with national agencies responsible for collection of loss and damage data; and (b) the scoping of the proposal to initiate a DRR project in Southeast Asia focusing on capacity development in risk analysis and Multi-Hazard Early Warning Systems (MHEWS) in line with the recommendations of the 2014 Meeting of the Presidents of Technical Commissions (PTC-2014; January 2014), to complement the existing relevant projects and activities, including the Severe Weather Forecasting Demonstration Project (SWFDP) in Southeast Asia, in order to avoid duplication.

Post-2015 Framework for Disaster Risk Reduction

3.3.6 The Commission noted that the term of the Hyogo Framework for Action (HFA) 2005–2015 was drawing to an end, and was informed that the Third United Nations World Conference on Disaster Risk Reduction (WCDRR-III, 14–18 March 2015, Sendai, Japan) would consider for adoption the post-2015 Framework for Disaster Risk Reduction. The Commission further noted that regional and global consultations are under way in 2014, facilitated by the United Nations International Strategy for Disaster Risk Reduction (UNISDR) and the regional socio-economic groupings for drafting of the post-2015 Framework for Disaster Risk Reduction. The Commission encouraged its Members to actively participate in and provide input to these national and regional consultations, as well as to the WCDRR-III event, to showcase: (i) the importance of operational meteorological, hydrological and environmental services in support of disaster risk reduction decision-making, through case studies and “success stories”; and (ii) technical capacities and challenges faced by Members in implementing impact-based forecasts and early warning systems in support of risk-informed decision-making. In this context, the Commission emphasized that the disaster risk reduction activities of Members were part of their service delivery mandates to ensure readiness, response and resilience, and therefore, requested its OPAGs to align their disaster risk reduction-related projects and activities with the WMO Strategy for Service Delivery.

3.4 Global Framework for Climate Services (agenda item 3.4)

3.4.1 The Commission noted that the extraordinary session of the World Meteorological Congress was held in Geneva, Switzerland in October 2012. The Extraordinary Congress adopted three resolutions pertaining to: (a) the Implementation Plan of the GFCS; (b) the establishment of the Intergovernmental Board on Climate Services; and (c) financing of the Intergovernmental Board on Climate Services, Secretariat and Implementation Plan of the GFCS. The Commission also noted that the first session of the Intergovernmental Board on Climate Services (IBCS-1) was held in Geneva from 1–5 July 2013 and that the Commission for Basic Systems (CBS) had contributed actively to the work leading up to IBCS-1.

3.4.2 The Commission took note of progress in the early implementation of the GFCS as part of the Implementation Plan (including its Annexes and Exemplars) and the compendium of initial GFCS projects approved by IBCS-1. In this regard, a number of countries were conducting their national consultations intended to identify gaps and needs and to establish the internal coordination mechanisms needed to ensure effective implementation of the Framework (see

http://gfcs.wmo.int/events). Regional consultations were also being conducted. These consultations allowed the identification of key gaps in the various components of the GFCS that needed to be addressed to support the development and application of climate services in the four priority areas. They also facilitated the identification of critical elements required for the development of guidelines for the establishment of frameworks for climate services at national level. The Commission noted the need to address the various aspects of the production and application of climate services in its operating plan for the sixteenth intersessional period through the identification of concrete support of CBS to the implementation of the priority activities of the GFCS to meet the targets defined for the 2-, 6-, and 10 year time frames. This will require coordination of ongoing and planned activities relevant to the GFCS within CBS and with other Commissions, as well as appropriate coordination with partner agencies.

3.4.3 The Commission noted the potential contribution of CBS to the IBCS structure. The Commission would be participating in the Meeting on the Implementation Coordination of the GFCS in Geneva on 29 September to 1 October 2014, to explore how WMO Technical Commissions and Programmes and partners could contribute to GFCS implementation activities. In this regard, the Commission requested its president to provide its views on the composition and functioning of the structure to be considered by the second session of the IBCS, scheduled from 10 to 14 November 2014. In addition, the Commission affirmed its desire to support the work of the Management Committee of the IBCS as and when appropriate.

3.4.4 The Commission noted that the Executive Council Task Team on WMO Policy for International Exchange of Climate Data and Products to Support the Implementation of the GFCS developed a draft resolution that was considered by the sixty-sixth session of the Executive Council prior to submission to the WMO Seventeenth Congress in 2015. The resolution reiterated and complemented Resolution 40 (Cg-XII) – WMO policy and practice for the exchange of meteorological and related data and products including guidelines on the relationships in commercial meteorological activities and Resolution 25 (Cg-XIII) – Exchange of hydrological data and products. It proposed the application of the policy and practices from these resolutions and in an Annex identified a set of data and products that should be exchanged in a free and unrestricted manner for the purposes of the GFCS (http://library.wmo.int/opac/index.php?lvl=notice_display&id=16315#.VA9zKWfxvZ4).

3.4.5 The Commission noted that early efforts to showcase partnerships in the development and application of climate services were taking place through specific activities. With funding from Norway (10 million USD), the GFCS Adaptation Programme in Africa was launched in October 2013. This programme aimed at co-designing and generating information and knowledge to support decision-making in food security and nutrition, health and disaster risk reduction with Malawi and the United Republic of Tanzania as the two focus countries, involving various partners. In addition, with the support from Canada (6.2 million USD) a Programme for Implementing the GFCS at regional and national scales was under formulation. The programme would support Pacific Island countries, countries in the Caribbean and South Asia, including Arctic and Polar Regions. Other programmes supported by various donors were being designed. The Commission noted that implementation of these projects required support from CBS to provide the technical capabilities to respond to the needs identified by the projects. In this regard, the Commission identified the need to discuss the linkage between CBS and GFCS projects on the ground. This Commission would have an opportunity to advance this discussion topic at the upcoming Meeting on the Implementation Coordination of the GFCS in Geneva, which would focus on the role of WMO bodies in country-specific GFCS project implementation, including those mentioned above.

3.5 Capacity development (agenda item 3.5)

Education and Training

Qualifications and competencies

3.5.1 The Commission recalled the request of Cg-XVI for the technical commissions to develop competency frameworks within their areas of expertise. The Commission recognized the

work undertaken by its various expert teams and working groups to develop competency frameworks within the PWS and WIS areas, and the discussions in the various Tropical Cyclone, Typhoon and Hurricane Committees under the regional associations related to competency standards for tropical cyclone forecasting (http://www.wmo.int/pages/prog/dra/etrp/competencies.php). The Commission noted the discussion at the sixty-sixth session of the Executive Council (EC-66) regarding the need for consistency of language, approach and structure in the competency standards that were being proposed. The Commission requested its Expert Teams and working groups to work with the EC Panel of Experts on Education and Training to ensure that the competency standards to be considered by the Commission were in-line with the agreed formats. The Commission noted the desirability of the approved competency standards being incorporated into the WMO Technical Regulations as recommended practices; unless there was an external regulatory requirement wherein they could become Standards. The Commission recognized that the approval of the competency standards provided a framework not only for common operational practices but also for developing and providing education and training. The Commission requested the WMO Regional Training Centres and other training institutes to use the agreed competency standards when developing international training courses.

Regional Centres

3.5.2 The Commission recalled the discussion in EC-66 regarding the outcome of the 26th session of the EC Panel of Experts on Education and Training including the review of the future role and responsibilities of WMO Regional Training Centres. The Commission noted with interest that the review had recommended a number of changes that could be of interest for regional centres approved through the Commission. The changes included definition of the roles and responsibilities of the parties involved in the nomination, approval and ongoing monitoring of regional centres, requirement for the regional centres to provide their host regional association and the Secretary-General with annual reports and plans, and the requirement for the regional association to review the status of the regional centre during each session of the Association and make recommendations to EC on whether the institute should continue as a regional centre (EC-66, Resolution 15 – EC Criteria for the recognition and reconfirmation of WMO Regional Training Centres (RTCs)). The Commission noted that these changes were consistent with Quality Management System (QMS) requirements and requested that its Management Group consider whether similar changes could benefit the processing and monitoring of regional centres approved through the CBS processes.

WMO Global Campus

3.5.3 The Commission recalled the discussion in EC-66 regarding the proposal for a WMO Global Campus (incorporating the RTC network) that would provide increased education and training opportunities for Members and new providers of education and training courses and resources. The Commission supported the feasibility study (http://www.wmo.int/pages/prog/dra/etrp/documents/final-report26thSession.pdf chapter 4.4 page 18) into the WMO Global Campus. The Commission encouraged its centres with training responsibilities such as RSMCs, RCCs, GISCs, to engage with the WMO Education and Training Office with the view to sharing their training resources with the wider ETR community with special attention to the copyright owners' prior permission and appropriate copyright display in accordance with their policies and potentially offering training for WMO Members and to contribute to the study on the WMO Global Campus.

WIGOS

3.5.4 The Commission noted with appreciation the increased emphasis being placed on providing education and training opportunities to WMO Members in all regions in the area of instrument maintenance and calibration through support from the Governments of Canada, China, Japan, Norway, Spain, Turkey and others. The Commission further appreciated the coordination and cooperation between a number of its Regional Instrument Centres and WMO Regional Training Centres in developing and delivering these courses. The Commission further noted that by the end of 2015 it is anticipated that well over 100 participants would have undertaken courses in instrument maintenance and calibration in English, French, Russian or Spanish representing a

considerable investment in assisting Members develop staff to improve the quality and quantity of observation data available to all Members.

3.5.5 The Commission noted that the WIGOS framework recognized the importance of capacity development, with a key activity area focused on support for WIGOS implementation. It encouraged the ICG-WIGOS to place an increased emphasis on capacity development during the WIGOS Pre-operational Phase, in conjunction with the ETR programme.

Capacity Development Strategy of the WMO

3.5.6 The Commission noted with satisfaction that a significant aspect of the Capacity Development Strategy (CDS) and its Implementation Plan (CDSIP) related to the work of the Commission to reduce the existing gaps in the basic systems of many Members. It further appreciated that over the last year the Secretariat and Members had focused resources to build capacity in WMO priority areas such as compliance with QMS requirements, regional WIGOS/WIS implementation, DRR and Climate Services.

3.5.7 The Commission noted its role in fostering a “culture of compliance” as a critical component of Capacity Development. To this end it encouraged further clarification of standards and their promulgation in a manner that assists Members to gain needed funding and political support for compliance with WMO Technical Standards, Guidance and Best Practices. The Commission also recognized the need for utilizing and reporting of accurate information regarding national capabilities using mechanisms such as checklists, surveys, and the Country Profile Database.

3.5.8 In order to utilize limited resources effectively and efficiently the Commission urged all Members to contribute or implement relevant parts of CDSIP, with particular emphasis on the development and implementation of WMO Technical Standards.

4. RECOMMENDATIONS FOR THE SEVENTEENTH WORLD METEOROLOGICAL CONGRESS ON THE KEY ROLE OF THE COMMISSION FOR BASIC SYSTEMS IN CONTRIBUTING TO FUTURE WMO PRIORITY AREAS (agenda item 4)

4.1 Key issues relevant to the Commission that have been identified by the Executive Council for the Strategic and Operating Plans 2016–2019 (agenda item 4.1)

Consideration of EC draft Strategic and Operating Plans 2016–2019

WMO Strategic Plan 2016–2019

4.1.1 The Commission recalled that the Sixteenth Congress requested technical commissions to:

(a) To lead the formulation of the scientific and technical aspects of WMO Programmes and activities falling within their respective responsibilities in preparing the WMO Operating Plan;

(b) To develop their own Operating Plans in support of the implementation of the next WMO Strategic Plan.

4.1.2 The Commission noted with appreciation the active involvement of its Members and the president of the Commission in the development of the WMO Strategic Plan 2016–2019 (SP) under the guidance of the Executive Council and its Working Group on Strategic and Operational Planning (WG-SOP), and with contributions from all regional associations (RAs) and technical commissions (TCs).

4.1.3 The Commission recalled that in December 2013 the Secretary-General communicated the draft Strategic Plan to all WMO Members for their input and indication on whether the capacity of NMHSs to provide services would be improved if the WMO followed the strategic directions proposed in the Plan, and if the Members would be able to use the Plan to inform the governments of the strategic directions and priorities of WMO.

4.1.4 The Commission further noted that the draft SP submitted to the Executive Council at its sixty-sixth session incorporated the views and inputs that had been received from constituent bodies of WMO and Members of the Organization. The following global WMO strategic priorities were formulated in the draft SP:

(i) Disaster Risk Reduction (DRR)

(ii) Service Delivery

(iii) Global Framework for Climate Services (GFCS)

(iv) WMO Integrated Global Observing System (WIGOS)

(v) Capacity Development

4.1.5 The draft Plan also recognized the significance of WMO's research priorities in the area of high impact weather, seasonal to sub-seasonal forecasting, polar prediction and urban meteorology as means of enabling improvements in operational service delivery. Furthermore, this were also true for advancements in monitoring and information technologies, in particular keeping WMO's Information System (WIS) current with WIGOS developments.

4.1.6 The Council considered the draft WMO Strategic Plan 2016–2019 and decided to recommend it to Congress with further improvements to:

(a) Simplify the topology of the document, making the priorities the centrepiece of the document and ensuring that they are explicitly linked to budget requests set out in the revised budget proposal;

(b) Have the following as possible priorities:

1. Improve the ability of NMSs to meet ICAO requirements focusing on accelerating the implementation of competency standards and QMS to: (a) meet the emerging needs of the global air navigation plan; (b) meet the emerging issues in WMO Regions; and (c) strengthen cost recovery frameworks;

2. Implement climate services under the GFCS Implementation Plan particularly for countries that lack them focusing on supporting the establishment of regional climate centres; identify user requirements for climate products; develop the Climate Services Information System (CSIS);

3. Complete the implementation of the WIGOS/WIS focusing on the implementation of all the building blocks of the framework and supporting the uptake at regional and national levels;

4. Implement operational polar weather, climate, and hydrological services focusing on operationalizing the Global Cryosphere Watch and advancing the Global Integrated Polar Prediction System (GIPPS);

5. Enhance the capacity development of NMHSs to deliver on their mission by helping them to enhance their human resources, technical capacities and their infrastructure, particularly in developing, least developed and small island developing states;

6. Improve expertise in providing high quality impact-based forecasts and, in particular, early warning of high impact weather, climate and water events, thereby contributing to international efforts on Disaster Risk Reduction and Prevention; and

7. Conduct a strategic review of WMO structures, operating arrangements and budgeting practices focusing on the effectiveness of constituent body activities and the Secretariat arrangements;

(c) Shorten and simplify the Strategic Plan, use action-oriented language and delete the appendices.

4.1.7 The Council requested the President to work with the Working Group on Strategic and Operational Planning to finalize the draft Strategic Plan by August 2014, in time for the preparation of the budget and further requested the Secretary-General to submit the Strategic Plan and budget to Seventeenth Congress for consideration.

4.1.8 The Commission noted that the Working Group on Strategic and Operational Planning had finalized the draft Strategic Plan according to the above EC guidance. While supporting the draft Plan, the Commission highlighted the following activities that were already captured but could be further strengthened in the Plan, namely: (a) Disaster Risk Reduction and its importance for the implementation of multi-hazard early warning systems for urban and megacity areas; (b) Service Delivery and the importance of observations and forecasts for transportation; (c) strengthening cost recovery frameworks; and (d) the importance of WIGOS implementation to all WMO priority areas.

WMO Operating Plan 2016–2019

4.1.9 The Commission recalled that the Sixteenth Congress had requested the technical commissions to prepare their operating plans to support the implementation of the WMO Strategic Plan. The Executive Council had further decided that the Organization should have a single integrated Operating Plan that includes the activities of RAs and TCs and incorporates their own operating plans. The Commission urged its president and Management Group to develop the Commission's operating/action plan for 2016–2019 and submit it as a contribution to the WMO Operating Plan (OP).

4.1.10 In order to ensure timely provision of the Commission's contribution to WMO integrated strategic planning process in the future, the Commission requested its president and Management Group to set up a process and develop and submit such contributions, as required, in consultation with members of the Commission during the intersessional period.

Monitoring and Evaluation

4.1.11 The Commission noted that the Secretariat continued to develop and implement the WMO Monitoring and Evaluation (M&E) System and that Executive Council encouraged constituent bodies to make use of the M&E System and Guide prepared by the Secretariat and provide feedback for further improvement. The Commission agreed to use the WMO M&E Framework as appropriate in the work of the Commission, and also to provide feedback to the Secretariat.

4.2 Recommendations on the role of the Commission in implementing the WMO Strategy for Service Delivery (agenda item 4.2)

4.2.1 The Commission recalled that, at the request of the sixteenth World Meteorological Congress (Cg-XVI, Geneva, 16 May–3 June 2011), the Secretary-General had arranged for the preparation of a draft Implementation Plan (IP) for "The WMO Strategy for Service Delivery" (herein referred to as "the Strategy") for approval by the WMO Executive Council. The sixty-fifth session of the WMO Executive Council (EC-65, Geneva, 15–23 May 2013) approved the English version of the Strategy and the IP, and welcomed its publication in March 2014. That publication

can be accessed freely on the WMO PWS website at the following link: http://www.wmo.int/pages/prog/amp/pwsp/documents/WMO-SSD-1129_en.pdf. The Commission expressed appreciation that the publication would also be translated into other official WMO languages.

4.2.2 The Commission was of the view that the ability of NMHSs to meet national service needs was put to its most critical test when an extreme hydrometeorological event occurred. Even the best forecast, issued on time, was not useful if, for various reasons, it did not generate the desired response from those at risk, and it had little impact. The delivery of warnings of severe weather to disaster management agencies and other partners, and to the public on an operational basis was at the heart of the mandate of NMHSs. For this reason, the Commission fully supported that NMHSs activities for disaster reduction and mitigation needed to be well integrated into their overall service delivery role.

4.2.3 The Commission noted that the Executive Council had urged Members to adapt and apply the Strategy and its IP to their own service delivery strategies and plans, for the delivery of quality services to all social and economic sectors in support of security of life, livelihood, property and national economic activities. It requested the PWS Programme to make every effort to assist NMHSs in the application of the Strategy in a realistic, pragmatic and concrete manner in the provision of services to the public and other users, and to organize regional seminars and conferences for the senior management of NMHSs in order to familiarize them with the IP.

4.2.4 The Commission agreed that a major issue of concern to NMHSs was the risk of their reduced visibility to end-users and policy-makers of the basic role performed by NMHSs as a consequence of increased delivery of services by the private sector providers. It emphasized that effective delivery of high quality services was a key element in ensuring their position as the service provider of choice, in particular, as the single official voice for forecasts and warnings of severe weather. Consequently, it requested that the PWS Programme should apply the principles contained in the Strategy and its IP to assist NMHSs in promoting delivery of high quality services to user communities and in improving their skills in communicating social and economic benefits to decision-makers, including guidance on negotiations and conclusions for service level agreements where some services could be delivered through mutual agreement.

4.2.5 The Commission drew attention to the clearly indicated roles and responsibilities of the constituent bodies in the IP. It recalled that the Executive Council had requested technical commissions to ensure that the Strategy was infused into all Programmes of WMO whose mandate included service delivery. Technical commissions could each help to contextualize service delivery improvement in their area of technical expertise through establishment of mechanisms to document and share best service delivery practices, to develop guidelines specific to excellence in the delivery of services in their specific areas of interest and to incorporate service delivery improvement initiatives in their workplans focused on service delivery to their specific user groups and audiences. The Commission agreed that NMHSs would directly benefit from this work through the improvement of their capabilities to deliver fit-for-purpose services according to their mandates. It noted that monitoring, evaluation and reporting would be required by constituent bodies to demonstrate that the Strategy was being implemented, that improvement was being achieved and that benefits were being delivered and measured. The Commission requested its OPAG/PWS to engage with the Implementation Plan of the WMO Strategy for Service Delivery and work with the other technical commissions and the regional associations to organize appropriate regional workshops, and monitor and evaluate the effectiveness of these.

4.3 Recommendations on Members' actions for the implementation of impact-based forecasting and risk-based warning (agenda item 4.3)

Moving towards forecasting impacts

4.3.1 The Commission acknowledged that despite the science, technology, data, and other resources that exist in the collective meteorological community, some recent severe weather and associated events had been the cause of many deaths and destruction of properties and loss of livelihoods. The question frequently asked was: how should we, as the meteorological community,

change what we are doing so that we can better contribute to mitigating the impacts of severe hydrometeorological events and in particular the loss of life. The Commission agreed that the primary responsibility of National Meteorological and Hydrological Services (NMHSs) was to provide timely and accurate forecasts and warnings of hydrometeorological events and hazards. However, in order for governments, economic sectors and the public to take appropriate action, they needed to know how the hydrometeorological hazard would impact their lives, livelihoods, property and the economy.

4.3.2 The Commission agreed that understanding disaster risk and forecasting hydrometeorological impacts was generally beyond the remit of meteorologists and hydrologists. However, since the risks and impacts associated with extreme weather events were dynamic, it might be argued that NMHSs were best equipped to forecast their impact. In some countries, those affected were demanding more than statements of expected weather conditions from their NMHSs (Ref.: CBS-15, Abridged Final Report, Annex VI). Solving this problem was a challenge to developing and developed economies alike. The risk associated with a hydrometeorological hazard depended on knowing how that hazard impacted human beings, their livelihoods, and assets due to their vulnerability and exposure. The sixty-fifth session of the WMO Executive Council (EC-65, Geneva, 15–23 May 2013, ref.: EC-65 – Abridged Final Report, general summary – paragraphs 4.1.26–4.1.38) discussed the NMHSs' move towards impact-based forecasting and risk-based warnings in the provision of public warning services in support of social resilience through behaviour modification in society.

Forecasting the changing risks of impact

4.3.3 The Commission noted that risk of harm due to a hydrometeorological event might be described as a combination of hazard, vulnerability and exposure, where hazard is defined as a hydrometeorological-based, geophysical or human-induced event that poses a level of threat to life, property or the environment; vulnerability refers to the susceptibility of exposed elements such as human beings and their assets that may be impacted by a hazard; and exposure refers to who and what may be impacted in an area in which hazardous events may occur. Actions taken to reduce the vulnerability and/or exposure would mitigate the risk of the impact of hydrometeorological hazard. Actions taken during the event would mostly affect exposure and will change the forecast of the impact on exposed elements.

An impact-based forecast – the elements

4.3.4 The Commission acknowledged that issues related to impact-based forecasting and risk-based warnings were complex and required planning and forging of partnerships at many levels and with many other government agencies and stakeholders: not only with disaster managers, but also with those responsible for urban planning, education authorities, health authorities, etc. These complexities often led to reluctance of meteorologists to forecast impacts since extensive knowledge of vulnerability and exposure were required and could only be addressed through data sharing among different agencies and departments. The Commission however agreed that forecasting the impact of the hazard (what the weather would do), was often more important than the meteorological forecast (what the weather would be) because it was defined in terms of parameters more readily understood by those at risk and those responsible for mitigating those risks. Such forecasts would ensure that critical weather information was communicated about societal impacts to individuals and sectors most at risk. This information should be made available to the community in a variety of easy-to-understand formats.

Risk-Based Warnings

4.3.5 Risk-based warnings address both the likelihood of a hydrometeorological hazard and its potential impact on people, property and infrastructure. An example of such an approach is illustrated in Annex XVI to the present report, where collaboration between the UK Met Office with other government agencies and first responders in the United Kingdom had resulted in the risk matrix used by the Met Office to identify the likelihood of an event and its potential impact.

Future Direction

4.3.6 The Commission noted that the Commission for Basic Systems Open Programme Area Group on Public Weather Services Expert Team on Meeting User Needs in Reducing the Impacts of Hydrometeorological Hazards (CBS/OPAG-PWS ET/DPM), in collaboration with other relevant CBS OPAGs, had prepared a set of WMO guidelines for NMHSs on developing multi-hazard impact-based information and warning services that was discussed under agenda item 3.3. The guidelines highlighted the challenges of impact-based forecast services and comprised examples and best practices of impact-based forecast and warning services.

4.3.7 The Commission emphasized that due to the emerging and somewhat unfamiliar nature of the subject, the guidelines needed to be introduced to Members in order to familiarize them with the challenges and issues involved. It decided therefore that, in parallel with the publication of the guidelines, the best way to demonstrate the steps needed to progress towards such forecasts was through organizing pilot projects for implementation by Members. In this regard, one approach was to engage with Members participating in the Severe Weather Forecasting Demonstration Projects (SWFDPs) who had acquired improved capability in forecasting and PWS delivery. The next logical step would be for them to extend their warnings and forecasting services to impacts of hazards. The Commission therefore requested the OPAG/PWS and the PWS Programme to work closely and in alignment with the other DRR and capacity development-related activities to assist Members with implementing impact-based forecasting and warning services through training workshops, and, where possible, pilot projects. The Commission was pleased to note that the PWS Programme planned to establish a pilot project in Regional Association I (RA I, Africa) to test and refine the new approach in one country in that region.

4.3.8 The implementation of The WMO Strategy for Service Delivery would be an important tool for integrating impact-based forecasting and risk-based warnings into a common planning framework to maximize benefits and allow for planning and maintenance of observing infrastructure, and efficient implementation of predictive services of Members in support of social resilience and mitigation of impacts. The PWS and underpinning observing capabilities of Members needed to be upgraded and strengthened on a continuous basis to cope with the optimum delivery of new services, ranging from day-to-day operations to providing guidance informing decisionmakers and policymakers on longer timescales. In this regard, the Commission requested that, through the application of the above guidelines, the OPAG/PWS assist Members with their activities for the implementation of a multi-hazard approach to reducing impacts.

4.4 Recommendations on the future of the Global Data-processing and Forecasting System (agenda item 4.4)

Consideration of Requests from EC-66 and Work of the ICT of the OPAG on DPFS

4.4.1 The Commission recalled the five WMO High Priorities established by Sixteenth Congress and committed to focusing its GDPFS work to support these priorities. In particular, it reaffirmed that the GDPFS contributes to many of the WMO's high priorities: (i) through the Severe Weather Forecasting Demonstration Project (SWFDP) and the use of Ensemble Prediction Systems (EPS) for predicting severe and high-impact weather that contribute to Disaster Risk Reduction and Capacity Development; (ii) through a network of centres that carry out global monthly and seasonal forecasts that are essential for the Climate Services Information System (CSIS) of the Global Framework for Climate Services (GFCS); (iii) through the use of applications of NWP/EPS such as atmospheric transport and dispersion modelling for environmental emergency response activities (ERA), thereby contributing to Disaster Risk Reduction; and (iv) through the provision of benefits to other socio-economic sectors, including aviation, agriculture, and marine safety.

4.4.2 The Commission noted with appreciation the work of the CBS experts and the ICT of the OPAG on DPFS during the intersessional period. The Commission agreed with the 2, 6 and 10 years' vision for the GDPFS proposed by the ICT (http://www.wmo.int/pages/prog/www/CBS-Reports/documents/ICT-DPFS-Ext_report-Jan2013.pdf) (as in Annex XVII to the present report),

wherein the GDPFS would be developed and expanded to cover all timescales, from short to multi-annual range. The Commission also agreed that the need for services for disaster risk reduction and for capacity development activities would require the GDPFS to enhance Members' capabilities for the production of timely warning of high impact weather, for the support of emergency response to nuclear and non-nuclear incidents and for early warning of climate anomalies on monthly, seasonal and longer timescales.

4.4.3 The Commission endorsed the detailed work plan for the OPAG on DPFS developed by its ICT which included activities related to operational weather forecasting process and support, operational predictions from sub-seasonal to longer timescales, emergency response and the revision of the Manual on the GDPFS (WMO- No. 485), as detailed below. This information would serve as the basis for monitoring the performance of the OPAG on DPFS.

4.4.4 The Commission noted the encouragement of the Executive Council at its sixty-sixth session (EC-66) to the effect that the GDPFS and its operational centres should be strengthened and further developed towards a seamless data-processing and forecasting to cover all forecasting timescales, and extended to include environmental-related predictions in support of service delivery and related application areas (ER-1). In this regard, the Commission considered that the evolution of DPFS – from the data processing and forecasting perspective through to the dissemination of information involving WIS/WIGOS – should be made in consideration on and collaboration with other technical commissions such as CAS (i.e. for nowcasting, polar predictions), JCOMM (marine forecasting), CAeM (aeronautical meteorology services), CAgM (agricultural services) and CHy (hydrological forecasting) and partners such as the transportation sector (road, rail, marine, aviation) to understand requirements and incorporate the latest developments. The Commission therefore requested the OPAGs to work closely with the relevant expert teams and groups to build a plan for future DPFS development for enhanced service delivery and applications.

4.4.5 The Commission noted the request by EC-66 to the Secretary-General and CBS, in consultation with Regional Specialized Meteorological Centres (RSMCs), for the development of a concise guide on actions to be taken by NMHSs in case of the run up of extreme weather-related events. The Commission requested its OPAG on DPFS to address this issue in coordination with the OPAG on PWS and by engaging other relevant technical commissions and programmes.

Severe Weather Forecasting Demonstration Project (SWFDP)

4.4.6 The Commission recalled that at CBS-15 it had stressed the importance to move SWFDP forward and to expand the scope and establish synergies for example with flood forecasting. The Commission noted that EC-66 had also encouraged closer collaboration of SWFDP with the Flash Flood Guidance System (FFGS), especially when in the same geographic region. The Commission noted with satisfaction the effort being deployed to integrate the Flash Flood Guidance System (FFGS) with the SWFDP in Southern Africa. The Commission pointed out that a successful integration in this mature SWFDP would facilitate integration in other regions of the globe.

4.4.7 The Commission recognized that SWFDP supported all WMO strategic priorities and agreed, as stressed by EC-66, that the broader implementation of its Cascading Forecasting Process would contribute to enhancing service delivery functions of NMHSs. The Commission therefore requested its OPAG on DPFS, in collaboration with the OPAG on PWS, to develop a mechanism of moving from the demonstration phase of SWFDP, once successful, to a sustainable operational implementation of severe weather forecasting services. The Commission agreed that this should focus on enhancing information access through web tools supported by RSMCs from any bandwidth internet connection, knowing that a number of Members had limited connectivity. In addition, the Commission requested the Secretary-General, with the support of the OPAG on DPFS and in consultation with other CBS OPAGs and technical commissions and programmes, to ensure that regular training and capacity development of NMHSs were coordinated and conducted to enhance skills and knowledge of new tools and techniques.

4.4.8 While noting that there were a number of demonstration projects underway in various technical commissions (SWFDP (CBS), CFIDP (JCOMM), AvRDP (CAeM/CAS), Polar Forecasting (CAS)), the Commission also acknowledged the lack of a plan for the integration of these initiatives into an operational component so as to enhance service delivery following a successful demonstration of capability. The Commission, therefore, requested its OPAG to work with other technical commissions and expert teams to develop a plan and procedures for the integration and operationalization of successful demonstration projects. The Commission also requested its Management Group to develop a process to ensure adequate coordination with other Technical Commissions in relation to demonstration projects related to disaster risk reduction.

4.4.9 The Commission noted the request by EC-66 to consider the ten recommendations of the Workshop to Assist in Sustaining National Meteorological Services – Strengthening WMO Regional and Global Centres (Washington DC, USA, June 2013), to guide the future development of the SWFDP and ultimately the evolution of the GDPFS. At the same time, the Commission noted that the 2013 meeting of the Presidents of Technical Commissions (PTC) had requested the president of CBS to develop a concept paper describing a proposal for a Programme to Strengthen Operational Centres (PSOC), which would be built upon the lessons learnt through the SWFDP, for consideration, feedback and potential synergies with other technical commissions and programmes. With the support of the Steering Group for the SWFDP, this concept paper had been prepared and discussed at the 2014 meeting of the PTC. Following the recommendation by EC-66 for describing a mechanism to strengthen operational centres, the Commission reviewed and updated the concept paper and adopted Recommendation 23 (CBS-Ext.(2014)) – Proposed mechanism to strengthen operational centres, build upon the lessons learned through the Severe Weather Forecasting Demonstration Project. This mechanism considered extending the range of and/or establishing synergies with targeted applications to broaden the benefits of the SWFDP and framework to other user sectors such as agriculture, health, water, and disaster risk reduction.

Operational Weather Forecasting Process and Support (OWFPS)

4.4.10 The Commission agreed the GDPFS is at the heart of the WMO operational system. In order to support adequately the high priorities of WMO, the GDPFS needed also to evolve, be flexible and adaptable so that it could respond efficiently to emerging needs. The Commission noted with satisfaction the progress made in the development of the WMO guidelines on impact forecasts and warning services and acknowledged the need to integrate risk information with the suite of meteorological information to equip operational forecasters to deliver impact forecasts and warnings. The Commission, therefore, requested its OPAG on DPFS, in collaboration with the OPAG on PWS, to include this aspect in its work plan. The Commission, through its Management Group, would initiate a process to develop a long-term vision for the GDPFS.

4.4.11 The Commission acknowledged and agreed to address the need to sustain and enhance quality and reliability of operational forecasting services with the latest development and findings, in particular, in the area of (a) guidance on access to high resolution NWP; (b) standard procedures for surface verification; and, (c) use of NWP for hazard risk management.

4.4.12 While noting that many advanced centres applied global and regional NWP (some with EPS, sophisticated post-processing and visualization systems), the Commission stressed that many NMHS still lack access to high quality NWP data. The Commission noted further that such data, including EPS data, were available on the WIS, and that the difficulties encountered by NMHS to gain access to this data were stemming mainly from limitations with data processing facilities. Therefore, it stressed the importance of continuing efforts for the development of capacities as required. In addition, the Commission insisted on the need of improving the quality of very short-range forecast (VSRF) generally and especially in convection prone areas like the tropical belts. Therefore it agreed to pursue efforts in making high quality VSRF systems widely available, including improved convection-allowing models.

Operational Prediction from Sub-seasonal to Longer-time Scales (OPSLS)

4.4.13 The Commission noted that the last intersessional period had seen a strengthened collaboration between CBS and the Commission for Climatology (CCl) on operational climate prediction, facilitated by the joint CBS/CCl Expert Team on Operational Prediction on Sub-seasonal to Longer-time Scales (ET-OPSLS) and the CCl/CBS Expert Team on Regional Climate Centres (ET-RCCs). The Commission noted with appreciation that CBS/CCl Workshop on "Operational Long-range Forecasting: GPCs and RCCs, in support of NMHSs and Regional Climate Outlook Forums (RCOFs)" was held in Brasilia, Brazil from 25 to 27 November 2013, to identify priorities for strengthening cooperation and enhanced exchange of data, methods and tools between GPCs and RCCs, and ways to improve operational practice in long-range forecasting, including in support of NMHSs and RCOFs. The Commission noted the recommendations of the workshop on the steps needed to strengthen the process of generating long-range forecasts through increased capability for synthesis of prediction information on global, regional and national scales.

4.4.14 The Commission noted that within the framework of the WWRP/THORPEX/WCRP research project on sub-seasonal to seasonal prediction (S2S), sub-seasonal forecasts were being submitted (in real time) to an S2S project database hosted at ECMWF. Recalling the request by Sixteenth Congress to the LC-LRFMME to extend its role to include the exchange of extended-range predictions, the Commission invited the ECMWF to support development of displays of multi-model extended-range products by providing the LC-LRFMME with access to the S2S project database.

4.4.15 The Commission noted that climate-sensitive socio-economic sectors had multi-annual to decadal or near-term planning timescales which were not currently well-served with prediction information. It recognized that the development of prediction information on climate variability and change on this timescale was required to fill a widely-acknowledged gap in information for decision-makers. In this context, the Commission recalled the recognition by EC-LXI that the role of some Global Producing Centres of Long Range Forecasts (GPCs) would be expanded to provide interannual to decadal predictions to the proposed GFCS, and that EC-LXI had also welcomed the statement from the UK Met Office that it would be willing to expand its GPC role to meet the new requirements. The Commission noted with appreciation that GPC Exeter had made considerable progress in this regard, with at least nine centres contributing to four real-time exchanges completed, and that graphical displays of the forecasts were available on a dedicated website hosted by GPC Exeter.

4.4.16 While noting the recent progress in the development of multi-annual to decadal prediction systems and the concerted efforts to coordinate informal exchange of real-time decadal predictions, the Commission recognized the current scientific limitations to predictive skill on these timescales and the anticipated contributions of WCRP and CCl in this regard. The Commission further recognized that there were some concerns regarding multi-annual to decadal predictions in view of operational services, including ensuring judicious use of the predictions, understanding their limitations and in their harmonization with national decadal outlooks prepared by NMHSs. The Commission noted that the CBS/CCl Expert Team on Operational Prediction for Sub-seasonal to Longer-time Scales (ET-OPSLS) that was reviewing proposals for the roles and functions of a Lead Centre for Near-Term Climate Prediction (LC-NTCP) required for the exchange under more formal arrangements, as well as for a minimum set of forecast and verification products. The Commission also noted that the roles and functions of LC-NTCP should be approved by the Management Group only after it had confirmed that the concerns regarding multi-annual to decadal predictions had been addressed.

Emergency Response Activities (ERA)

4.4.17 The Commission recalled that EC-66 had agreed that collaboration with International Atomic Energy Agency (IAEA) should continue in relation to the review and revision of meteorological and hydrological aspects in the safety-related guides. The Commission noted the IAEA's Action Plan for Nuclear Safety called for an expanded mandate of its Incident and

Emergency Centre (IEC). The Commission noted with satisfaction that a Memorandum of Understanding between WMO and the IAEA had been revised in line with EC-66's direction to WMO to provide meteorological and hydrological support in relation to the IAEA/IEC's expanded role. Of particular importance was the identification, if required, of a WMO expert to assist the IEC in case of emergency.

4.4.18 The Commission noted the "private" ensemble exercise led by the RSMC Vienna on 18 April 2012 with the participation of nine RSMCs using the Joint Research Centre (JRC) ensemble platform, a platform that offers a very good functionality to display and compare model results, and the needed flexibility to serve scientific as well as operational users. The Commission agreed that this was a good way for participants to inter-compare and validate their models. The Commission therefore agreed with the plan to hold additional exercises to prove the concept, urged all related RSMCs to participate and thanked RSMC Vienna for its coordinating role. The Commission also requested the OPAG on DPFS in collaboration with RSMCs and the Secretariat to strive to operationalize ensemble atmospheric transport modelling, following successful results of exercises.

4.4.19 The Commission recognized the increasing sophistication of the atmospheric transport models used in the RSMCs, and the importance of full and correct interpretation of this information by forecasters in NMHSs, and recalled that at its fifteenth session the Commission had requested Members who host RSMCs to consider the provision of appropriate training courses in the use and interpretation of their guidance and products. The Commission noted that this request had been reiterated by Regional Associations (RAs) II, IV and VI. The Commission recalled that workshops on the use and interpretation of RSMC products had been conducted in the past by RSMCs Montreal, Washington, Melbourne, Exeter and Toulouse. However, considering that such face-to-face training workshops required significant human and budgetary resources, and that they might not reach a large audience, the Commission agreed that e-learning modules and web-based courses might be more appropriate and requested the OPAG on DPFS in collaboration with RSMCs to liaise with the Secretariat in addressing this requirement. The Commission also requested RSMCs to consider updating their training materials and to take advantage of training sessions conducted by SWFDP in their regions.

4.4.20 The Commission noted with satisfaction that the ERA website had been updated. It also noted that full contact information including e-mails were missing for a number of Member Countries despite the circular letter sent by WMO Secretary-General to Permanent Representatives to provide confirmation or nomination of contacts for its Delegated Authority, and for its Operational NMHS Contact Point, including name, title, telephone and fax number, and only one operational email address. Considering the limited response and continuing difficulty for RSMCs to reach NMHS contacts by fax, the Commission requested the Secretary-General to pursue the endeavour to obtain an updated list of contacts.

4.5 Recommendations on standardizing data management to support WMO (agenda item 4.5)

Standardizing Vocabularies

4.5.1 The Commission noted that the Executive Council at its sixty-sixth session (EC-66), the Intercommission Coordination Group on WIGOS (ICG-WIGOS) and the Presidents of Technical Commissions at their meeting in 2014 had recognized the importance of using standard vocabularies and terminology when exchanging information, data and products between programmes, and that the Global Framework for Climate Services (GFCS) and the Group on Earth Observations (GEO) would have requirements for standardization beyond WMO Programmes. EC-66 had agreed that the WMO should drive the process of establishing governance and take responsibility for hosting and maintaining such vocabularies needed for metadata management. The Commission agreed that CBS should lead in the definition of such vocabularies for the disciplines of weather, water and climate, in conjunction with other technical commissions as required.

Identifying objects

4.5.2 The Commission noted that EC-66, ICG-WIGOS and the Presidents of Technical Commissions (PTC) had each noted needs for uniquely identifying objects such as stations or documents, and that such identifiers would be most useful if they could be used directly to access further information about the object or to obtain the object itself. The Commission noted that examples of such identifiers were the station and equipment identifiers that have been proposed for WIGOS. The Commission noted that further work was needed to clarify the exact requirements and whether it would be necessary for WMO to manage its own system of identifiers, or whether it would be feasible to use systems operated by other organizations.

Recommending data management practices

4.5.3 The Commission noted that EC-66 and ICG-WIGOS had identified a need to standardize data management practices across programmes and to advise Members on good practice, and referred the matter to CBS for further study, in conjunction with CCl. This did not fall directly within the scope of the WMO Information System that was limited to the description and exchange of information, but the activity aligned with the responsibilities of OPAG-ISS. The Commission decided that the scope of the WIS should be extended to include guidance on the technical framework to support data management throughout the lifecycle of the data. The Commission requested its OPAG-ISS to coordinate with CCl and other interested technical commissions in developing the guidance.

Data management centres

4.5.4 The Commission recognized that users wished to be able to retrieve information from a single location and that there was a need for long-term preservation of information. Although some Programmes had designated centres to provide archive facilities for information that was shared globally, there were no common WMO standards for how such centres should operate.

4.5.5 The Commission recommended that in order to ensure the integrity, accessibility and availability of information, it would be appropriate for the WIS to develop a “Part C” to set auditable standards for centres providing long-term access to data held on behalf of WMO Programmes.

4.5.6 The Commission approved Recommendation 24 (CBS-Ext.(2014)) – Standardization of data management practices.

5. ANY OTHER BUSINESS (agenda item 5)

5.1 The WMO’s Deputy Secretary-General, Mr Jeremiah Lengoasa, addressed the session and highlighted the critical role of CBS in implementing the WMO priorities of WIGOS and WIS as well as its role in assisting Members to achieve seamlessness in services capabilities, across both timescales but also across domains and user communities.

5.2 Mr Lengoasa noted that the 2014 extra-ordinary session of the Commission for Basic Systems had approved 3 resolutions and 24 recommendations that would not just guide the work of the Commission but also feed into the decisions undertaken by Seventeenth Congress (2015).

5.3 He noted the important role of the CBS key areas like GFCS, SWFDP, WIGOS and WIS, PWS and the need to link them with other capacity development projects through collaboration with other Technical Commissions and organizations.

5.4 He stressed the need to strengthen linkages to the Regional Associations and noted that this provided a connection to Members.

5.5 He also highlighted the expenditure that other UN and development agencies were putting into observation and early warning system infrastructure such as the $250,000,000 UNDP

was spending in Africa and the $100,000,000 being spent on SIDS projects. He highlighted the need to assist Members NMHSs to connect with these efforts and share data to bolster their own services capability.

5.6 Mr Lengoasa noted that CBS provided an end-to-end operational capability from observations to services delivery, and that it was clear the Commission was delivering on that mandate as laid out in its Terms of Reference.

5.7 He emphasized how important it was that CBS was strengthening its collaboration with Regional Associations and the other commissions. This was evident by the Session being held adjoint to RA-III and by sharing a TECO and RECO. He recognized the attendance by the Presidents of RA-III and RA-VI, the Vice President of RA-IV and the President of CIMO. He thanked the Members' delegations and those of international organizations such as EUMETSAT, ECMWF and ICAO for their participation.

Future of Service Delivery

5.8 Over the course of the session, and within the TECO/RECO sessions, the Commission had multiple discussions on the importance of service delivery to the future of NMHSs. The Commission noted the value that could be provided via a seamless approach that embraces all aspects of service delivery. It also noted that there were elements of service delivery tied to other constituent bodies of the WMO.

5.9 The Commission appreciated that this remained a very complex issue. Within its own activities and structure, the Commission recognized that all OPAGs, and especially the OPAG-PWS and the OPAG-DPFS were closely tied to service delivery. It also noted its connection to many existing activities such as the SWFDP, DRR and its contributions to the GFCS.

5.10 The Commission requested its Management Group to establish a Task Team to examine these issues and develop a report that could be made available to Seventeenth Congress (Cg-17) which would provide a reflection on the issues regarding a holistic reorganization of service delivery within CBS and also how it would relate to other WMO constituent bodies. The Commission recommended collaboration and coordination with the Presidents of Technical Commissions and Presidents of Regional Associations, the Executive Council Working Groups on the Strategic and Operating Plans, Service Delivery and its Task Team on Continuous Improvement of Processes and Procedures, and with Members of WMO. The report should be a living document that would evolve taking advantage of the collaboration efforts. Following Cg-17, it would continue to evolve with the view of providing guidance to assist CBS-16 in its decisions regarding the structure and responsibilities of the Commission.

Timing of Sessions

5.11 As at previous sessions, the Commission had considered the need for meetings of the Commission every two years. Although CBS extraordinary sessions had had specific significant goals, the Commission had needed to advance operational matters across all CBS responsibilities and activity areas. CBS had responsibility for regulatory material including standards and practices that were central to the operation of Members' NMHSs and provided timely information important to the ongoing technological evolution of NMHSs. These include the WMO priorities, including WIS WIGOS and the GDPFS. Implementation of these priorities would bring about changes to WMO. The challenge for CBS is to guarantee the development of the basic systems infrastructure, and basic services, in support of all programmes.

5.12 The Commission recognized that the extraordinary sessions as they had generally been held had been effectively regular sessions without elections. It noted the convention and general regulations did not provide for regular sessions without elections. They also did not allow for decisions to be taken in technical conferences. Nor did they provide any other mechanism for most of the decisions and recommendations undertaken at the Commission session level. "Fast track" procedures had been granted for some limited purposes and Congress had granted the Executive

Council authority for some types of decisions. However, these lower level decision authorities were limited.

5.13 The Commission recognized the pace of change of technology and operational practice was very rapid and was unlikely to slow. It considered its responsibility to provide operational support to Members. It noted that leading into Congress, such as at CBS Ext.(2014), the Commission had to prepare many recommendations and resolutions for Congress decisions involving regulatory matters and other matters impacting Members activities. It also noted that following Congress, the Commission had to reorganize its work plan and structures to address the decisions of Congress.

5.14 The Commission recognized that it had already achieved a reduction in the length of sessions, through increased efficiency and improvements in the decision making process, while handling an increased workload. It also concluded that the constraints of the decision-making process within WMO required it to continue to meet every two years in order to match the pace of changes in technology and user requirements. Seeking to become even more effective, the Commission requested its Management Group to consider further improvement to procedures for making changes to technical regulations and the changes to the regulatory regime that would be needed to enable this, in coordination with the EC Task Team on Continuous Improvement.

Feedback on the Commission Session

5.15 The Commission noted the effort by the Management Group and Secretariat to continually improve the mechanisms and procedures used to organize and run a session. It also noted that a web-based form had been provided to make providing feedback easier. The Commission encouraged all participants at the session to provide feedback via this form.

6. DATE AND LOCATION OF THE NEXT SESSION (agenda item 6)

The Commission had not received any declaration of intent to host the next session of CBS, but identified a need for a session in the fourth quarter of 2016. It was noted that the date and place of that session shall be determined by the president of the Commission after consultation with the Secretary-General according to General Regulation 188.

7. CLOSURE OF THESESSION (agenda item 7)

The 2014 Extraordinary session of the Commission for Basic Systems was closed at 5 p.m. on 12 September 2014.

RESOLUTIONS ADOPTED BY THE SESSION

Resolution 1 (CBS-Ext.(2014))

WMO GUIDELINES ON MULTI-HAZARD IMPACT-BASED FORECAST AND WARNING SERVICES

THE COMMISSION FOR BASIC SYSTEMS,

Noting that, despite the advances in science and technology, severe weather and associated events still cause many deaths and lead to the destruction of properties and the loss of livelihoods,

Noting further:

(1) That understanding disaster risk and forecasting hydrometeorological impacts is generally beyond the remit of meteorologists and hydrologists and requires close collaboration between National Meteorological and Hydrological Services and partner agencies within government and elsewhere,

(2) That the risk associated with a hydrometeorological hazard depends on knowing how that hazard has an impact on human beings, their livelihoods and assets, which in turn will depend on their vulnerability and exposure,

(3) That the Executive Council discussed the move of National Meteorological and Hydrological Services towards impact-based forecasting and risk-based warnings in the provision of public weather and warning services, in support of social resilience,

Considering the development by the Open Programme Area Group on Public Weather Services of a set of WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services, as contained in the annex to the present resolution,

Decides to endorse these Guidelines and to request their publication and wide distribution as a means of providing advice and assistance to Members in their move towards impact-based forecasting;

Requests the Open Programme Area Group on Public Weather Services, with assistance from the Secretariat and the regional associations, to provide support to Members in the application of the principles and methodologies described in the Guidelines and on how best to collaborate with their partners in establishing the basis for impact-based forecasting and risk-based warnings.

Annex to Resolution 1 (CBS-Ext.(2014))

THE WMO GUIDELINES ON MULTI-HAZARD IMPACT-BASED FORECAST AND WARNING SERVICES

The WMO Guidelines on Multi-Hazard Impact-Based Forecast and Warning Services

WMO-No. XXXX

World Meteorological Organization
Weather • Climate • Water

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This Publication can also be accessed in .pdf format at the following web-link:
http://www.wmo.int/pages/prog/amp/pwsp/publicationsguidelines_en.htm

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EXECUTIVE SUMMARY

Each year the impacts of severe hydro-meteorological events around the earth give rise to multiple casualties and significant damage to property and infrastructure, with adverse economic consequence for communities that can persist for many years. All this happens in spite of the fact that many of these severe events have been well-forecast, with accurate warning information disseminated in a timely fashion by the responsible NMHS.

The reasons for this apparent disconnect lie in the gap between forecasts and warnings of hydro-meteorological events and an understanding of their potential impacts, both by the authorities responsible for civil protection / emergency management and by the population at large. Put simply, while there is a realisation of what the weather might be, there is frequently a lack of understanding of what the weather might do.

If this gap is to be closed, then an all-encompassing approach to observing, modelling and predicting severe hydro-meteorological events, and the consequent cascade of hazards through to impacts, needs to be developed. Tackling this problem will require a multi-disciplinary and highly integrated and focused endeavour. This is essential to ensure access to the best possible science, and the optimum services, to manage multi-hazard events today, and to provide the best possible evidence base on which to make the costly decisions on infrastructure needed to protect the population in the future as climate changes.

Improving the understanding of the potential impacts of severe hydro-meteorological events poses a challenge to NMHSs and their partner agencies, particularly Disaster Reduction and Civil Protection Agencies (DRCPAs). These Guidelines establish a roadmap which identifies the various milestones from weather forecast and warnings to multi-hazard impact-based forecast and warnings services.

For completeness these Guidelines also describe the ultimate step of forecasting actual impacts, although it is recognized that this is a highly sophisticated exercise, requiring strong collaboration with partner agencies and significant research into exposure and vulnerability. For many Members this step will not be the responsibility of the NMHS but rather of the relevant DRCPA and other partners.

Progressing from weather forecasts and warnings to multi-hazard impact-based forecast and warning services represents a paradigm shift in service delivery for many NMHSs, but one which is entirely consonant with the Implementation Plan for the WMO Strategy for Service Delivery adopted by WMO in 2013. To assist Members with this process the Guidelines include many examples which help to illustrate the nature of the changes described, and include a section on a possible approach to change management of relevance in this context.

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CHAPTER 1: THE CASE FOR IMPACT-BASED FORECASTING

It is no longer enough to provide a good weather forecast or warning, people are now demanding information about what to do to ensure their safety and protect their property.

1.1 Coping with Hydrometeorological Multi-Hazards

Within the World Meteorological Organization (WMO) community, scientific advances in weather forecasting have afforded the ability to provide reliable warnings of hydrometeorological multi-hazards at an accuracy and lead time that should directly fulfil the mission of National Meteorological and Hydrological Services (NMHSs): to provide warnings of hydrometeorological hazards in support of safety of life and mitigation of damage to property. In order for governments, economic sectors and the public to take appropriate action, they need to know how hydrometeorological multi-hazards might impact their lives, livelihoods, property and the economy.

Many people still lose their lives, and socio-economic costs associated with hydrometeorological hazards continue to rise, due, in part, to a lack of appreciation and understanding of the impacts and consequences of hydrometeorological multi-hazards to well-being.

How should WMO Members change what they are doing to solve this problem? And, in doing so, how can they contribute to economic growth by taking advantage of science, technology, data and other resources from within the meteorological community and elsewhere to strengthen societies' capacity to cope with hydrometeorological multi-hazards?

1.2 Desired Outcomes

The utility of services and warnings is based on the ability of people to use the information and take effective action. Hence, institutional strengthening and improving observing and forecasting systems and quality of hydrometeorological warnings are a necessary, but not sufficient, prerequisite to drive down adverse impacts. In summary, an accurate and timely hydrometeorological warning does not guarantee safety of life or prevent major economic disruption (see Box 1 below).

NMHSs need to work more effectively with disaster reduction and civil protection agencies (DRCPAs), as well as with the public and stakeholders, to help people understand how hazards can impact them to ensure appropriate actions. By including the vulnerability of infrastructure to hydrometeorological multi-hazards and the likely behaviour of people during an emergency, NMHSs could help minimize the adverse impacts due to fatalities, damage and loss associated with these hazards.

While acknowledging the primary focus on safety of life and property, NMHSs also need to respond to the needs of business for effective services to deliver economic growth and sustainability; growth that depends on exploiting beneficial impacts of weather, and avoiding the adverse impacts.

1.3 Impact-based Forecasting

The issues described above could be addressed so as to convey what the impact of a hazard, or multi-hazards, may be to an individual or community at risk. Examples include forecasting the possible impact on road users of rainfall during the rush hour, or the impact on passengers of closing an airport due to strong winds. These could be done in a subjective way working alongside transport customers, or an objective way through developing an impact model using vulnerability and exposure datasets as well as meteorological information. Understanding disaster risk and forecasting hydrometeorological impacts is generally beyond the remit of meteorologists and hydrologists. However, since the risks and impacts are often triggered by extreme hydrometeorological events, it may be argued that NMHSs are best equipped to forecast their impact in partnership with others. In some instances, NMHSs may play a supporting role in providing hydrometeorological information to enable their partners to forecast impacts.

Box 1

Why do good weather forecasts result in a poor response?

There are numerous examples where the meteorological hazard was well forecast, but the impact was not properly considered and/or underestimated and the response inadequate. Two cases illustrate the need to move beyond weather warnings.

Case 1 – Tropical Cyclone Haiyan (Yolanda)

The most notable recent example is Tropical Cyclone (TC) Haiyan (Yolanda), which struck the Philippines as a Category 5 storm on 7 November 2013. As of 14 January 2014, 6,201 people were reported dead, 28,626 injured and 1,785 are still missing. More than sixteen million were affected and the current estimate of damage to infrastructure and agriculture is more than US$ 827 million (NDRRMC 2014). Many of the deaths were caused by the storm surge that resulted from the wind, which reached a maximum ten-minute sustained velocity of 275 km per hour. Would lives have been saved with better knowledge of the specific impacts of this storm? Most likely, yes. Accurate warnings were issued by the meteorological agency – PAGASA – for heavy rain and winds in time, and the government deployed planes and helicopters to the regions most likely to be affected. However, this was still not enough. Had there been better knowledge of the risks, particularly of the storm surge, it is likely that more extensive evacuations from exposed areas could have taken place sooner (Report of the Post-Typhoon Haiyan Expert Mission, WMO 2014).

Case 2 – Tropical Cyclone Fitow

Although much less intense than Haiyan, Tropical Cyclone Fitow underscores some of the limitations of weather warnings.

TC Fitow began to impact the Chinese mainland on 6 October 2013 causing significant damage and disruption. Between 2000 local time on 7 October and 1400 local time on 8 October, Shanghai received total precipitation of 156 mm, which is the most rainfall in 18 hours recorded since 1961. The impact was very significant: 97 roads were flooded; 900 communities were flooded with many underground parking facilities and cars damaged; and some flood prevention walls were damaged and others destroyed. Overflowing rivers flooded four districts. By 11 October, there were over 1.2 million people directly impacted with one reported death; and nearly 28,000,000 hectares of farmland was inundated. The direct economic loss is estimated at 890 million RMB. In the Zheijang Province, seven deaths were reported and the direct economic loss is estimated at over 33 billion RMB.

The China Meteorological Administration/Shanghai Meteorological Service (CMA/SMS) issued accurate warnings according to standard operating procedures and protocols, increasing the severity from blue to red as the situation worsened. Over 18 million people were alerted.

However, the public response was ‘why were the warnings so late’?

The orange alert for rainfall was issued at 0536 local time on 8 October and the red alert at 0738 local time. This day coincided with the first day of school and work after the Chinese national holiday. The time of issuing the highest alerts coincided with rush hour – the morning commute was well underway before many people were aware of the severity of the situation.

Gridlock prevented people from either getting to their destinations or returning home.

Why, if the forecast was so accurate, did this happen?

As in most countries, China bases its warning system primarily on meteorological thresholds.
Each warning level also includes a summary of recommended actions to be taken when the warning is issued. These actions are usually quite general and do not provide specific guidance for a particular circumstance. The forecaster does not usually consider the vulnerability and exposure of the population to the hazard. In the case of Fitow, this meant that the highest level of warning was not issued until well into the morning rush hour when the appropriate meteorological thresholds were exceeded.

Successful impact-based forecasting requires collaboration with others who have the additional necessary expertise, resources and knowledge (such as demographic data, crowd sourcing techniques, Geographical Information Systems (GIS), interoperability, third-party data integration and usage) to deliver impact services that NMHSs cannot do alone. From the perspective of service users, this would include communities most vulnerable to disasters contributing to the information system. Working closely together, the suppliers of the services and the beneficiaries of those services would provide an integrated authoritative, unified voice that everyone can resonate with, and in turn can take effective action.

The purpose of these guidelines is to outline a roadmap to assist WMO Members to further develop their forecast and warning services in a manner which allows the consequences of extreme weather hazards to be fully understood by users, and appropriate mitigating actions to be undertaken. This roadmap defines several steps as outlined in the text to achieve the above purpose. Recognizing that each successive step implies increasing complexity, and requires greater collaboration with relevant partner agencies and the incorporation of data beyond that which is normally used in providing warnings of hazards, special care has been taken in the preparation of these guidelines to clearly indicate the challenges and requirements involved with each of these successive steps. These guidelines complement existing forecasting and warning services in a manner that is aligned with *The WMO Strategy for Service Delivery and Its Implementation Plan* (WMO-No. 1129), and are designed to help NMHSs remain relevant and more responsive to changing societal needs; thus fulfilling their role as the authoritative voice that people want to hear and understand, and promoting access to sustainable private sector and donor investment.

CHAPTER 2: KEY CONCEPTS IN IMPACT-BASED AND IMPACT FORECAST AND WARNING SERVICES

Historically, all NMHSs have featured forecasting of the weather as central to their mission, and most also issue weather warnings in the case where hazardous weather is expected. In the case of both weather forecasts and warnings, the focus is on what the weather will ***be***. These guidelines advocate evolving from this weather-based paradigm to one which is focused primarily on forecasting impacts. In other words, the focus should evolve to what the weather will ***do***.

Some of the concepts which underpin the idea of Impact Forecasting go beyond the terms traditionally used in weather forecasting. Below, the critical terms are defined for the purpose of these guidelines.

2.1 Hazard

A hazard is defined as a hydrometeorological-based, geophysical or human-induced element that poses a level of threat to life, property or the environment.

2.2 Hydrometeorological Forecast Uncertainty

Hydrometeorological forecast uncertainty refers to the limits of predictability imposed by the state of the science and inherent randomness of the hydrometeorological system. In subsequent sections, this Guideline will explain more specifically how hydrometeorological forecast uncertainty integrates with factors related to exposure and vulnerability to assist in the quantification of risk.

2.3 Exposure

Exposure refers to who and what may be impacted in an area in which hazardous events may occur. If the population and economic resources were not located in (exposed to) potentially dangerous settings, no disaster risk would exist. Exposure is a necessary, but not sufficient, determinant of risk. It is possible to be exposed, but not vulnerable; for example, by living on a floodplain, but having sufficient means to modify building structure and behaviour to mitigate potential loss. However, to be vulnerable to a hazard, it is also necessary to be exposed. Exposure is time (t) and space (x) dependent.

An example of exposure related to geographic location would be a vehicle driving across a bridge during a windstorm. To highlight a situational example, a crane will have a much higher exposure during the same windstorm than would a car at street level. Exposure due to timing may exist at various time scales. For example, a windstorm that strikes during the peak of an urban rush hour would result in a much higher exposure factor than the same windstorm that hits an unpopulated rural area in the middle of the night.

2.4 Vulnerability

Vulnerability refers to the susceptibility of exposed elements, such as human beings, their livelihoods and property to suffer adverse effects when impacted by a hazard. Vulnerability is related to predisposition, sensitivities, fragilities, weaknesses, deficiencies, or lack of capacities that favour adverse effects on the exposed elements. Vulnerability is situation specific, interacting with the hazard to generate risk. Therefore, vulnerability may also be time and space dependent.

For example, as flood defences are built they protect the population in low-lying areas. As another example, the State of Florida in the United States of America (USA) implemented stricter building codes following Hurricane Andrew in 1992.

2.5 Risk

For purposes of these guidelines, risk is defined as the probability and magnitude of harm attendant on human beings, their livelihoods and assets because of their exposure and vulnerability to a hazard. The magnitude of harm may change due to response actions to either reduce exposure during the course of the event or reduce vulnerability to relevant hazard types in general.

Risk may be mathematically expressed as:

$$|\textit{Risk of Impact (x, t)}| \equiv |\textit{Hazard (x, t)}| \cup |\textit{vulnerability (x, t)}| \cup |\textit{exposure (x, t)}|$$

where ∪ is the union of the level of hydrometeorological forecast uncertainty, the degree of vulnerability, and level of exposure. Risks:

- can be connected to each other and their effects can be compounded. Several or many risks can occur simultaneously within the same area. This requires an ability to compare them and to make trade-offs, assessing the relative importance of one risk in comparison to another, which may not necessarily be hydrometeorological in character;
- are not always easy to identify, quantify and categorize, and sometimes identification occurs long after serious adverse consequences have been felt;
- are evaluated differently in social terms. Thus, a risk considered serious in one place may be considered less so in another, or there is flexibility in accepting the risk.

2.6 Weather, Impact-Based, and Impact Forecasts and Warnings

We define these three (3) separate forecasting paradigms for clarity; there is a subtlety in the distinctions amongst them:

Paradigm 1 – Weather Forecasts and Warnings (hazard only): These types of forecasts and warnings contain information that refers only to atmospheric variables and how they are expected to change. In the case of weather warnings, the focus is on forecasting weather-based hazards only.

Example 1: “Bora winds are expected tonight with wind speeds of 20 meters per second.”
Example 2: “Severe thunderstorms are expected today with wind gusts exceeding 60 mph.”

Paradigm 2 – Impact-Based Forecasts and Warnings (hazard and vulnerability only): These types of forecasts and warnings are designed to express the expected impacts as a result of the expected weather.

Example 1: "Bora winds are expected tonight which may result in delays or cancelation to ferry services."
Example 2: "Severe thunderstorms with gusts over 60 mph will result in damage to trees and power lines".

Paradigm 3 – Impact Forecasts and Warnings (hazard, vulnerability and exposure): These types of forecasts and warnings are designed to provide detailed information down to the individual, activity or community level. For many NMHSs, these types of forecasts will be the purview of partnering agencies rather than the role of the NMHS itself.

Example 1: "Ferry services for the island of Brač will most likely be cancelled tonight due to Bora winds."
Example 2: "Extensive traffic delays in Kensington may occur due to the risk of large trees downing power lines and blocking roads as a result of severe thunderstorms.".

Important to note is that knowledge of local *exposure* (i.e., known ferry routes and neighbourhoods with particularly large trees overhanging power lines) is required in order to formulate Impact Forecasts.

2.7 Service Delivery Partnerships: Public and Government Responsibility

Service delivery partnerships refer to interactions required among NMHSs, DRCPAs and other actors within local, municipal or national governments to implement an Impact Forecast and Warning System. In some countries NMHSs are empowered to serve in the capacity of describing impacts as well as forecasting the weather. However, in others, DRCPAs retain the authority for Impact Forecast and Warning. In these cases, strong partnerships need to be established so that the full benefits of Impact-based Forecast and Warning services can be realized.

CHAPTER 3: EVOLVING TOWARDS IMPACT FORECASTING

3.1 General Forecasts

All NMHSs have, as part of their basic duties, the responsibility to prepare general forecasts for their areas of responsibility. These forecasts are statements of the expected evolution of sensible atmospheric variables such as wind, temperature, humidity, precipitation, etc. Forecasts may be provided in either a deterministic or a probabilistic manner. The change to a more probabilistic approach has grown substantially with the advent of ensemble prediction systems. Communication of forecasts has evolved from forecast provision on a regular schedule (e.g., updated four (4) times daily) to a paradigm where they are updated almost continuously, via written text, graphics, radio and – with the advent of wireless technologies – text messages, e-mails and mobile applications.

Example from the Hong Kong Observatory (HKO), Hong Kong, China

The Hong Kong Observatory (HKO) provides weather forecasts to the public, shipping community, the aviation sector, and other special users through a variety of dissemination channels, including the Observatory's website, mobile application 'MyObservatory', the Dial-a-weather service, press, radio, TV and social-networking websites. TV programmes are produced and presented daily by professional meteorologists from the Observatory for TV broadcast. Radio interviews are also conducted by forecasters and weather service officers from the Observatory on the latest weather situation.

The HKO also provides automatic weather forecasts based on Numerical Weather Prediction (NWP) models. The output from computer models is processed and integrated automatically to generate the location-specific forecasts so that the public can better grasp weather changes at the regional level.

3.2 Warnings Based on Fixed Meteorological Thresholds

Many NMHS' have in place warnings to address significant hazards that are expected to threaten life or property. This next level of information includes messages that are provided on a non-routine and as-needed basis. In general, these products feature provision of specific headline messages, a colour-coded or numbering system, and/or activation of specialized public messaging systems that are only used during extreme events. Hydrometeorological events for which such warnings are provided may include flooding, winter storms, severe convective weather, extreme temperatures and poor air quality.

While messaging within warnings often describes expected impacts to the public and DRCPAs, the driver for issuing these early warnings is often based on weather-based factors only (e.g., winds speeds of at least "X" km/hour, snowfall totalling at least "Y" cm.) and can often be expressed as a probability of a fixed threshold being reached or exceeded (e.g., there is a 60% probability of winds speeds of at least "X" km/hour being reached).

Example from the United States National Weather Service (NWS)

NWS utilizes the Saffir-Simpson scale (http://www.nhc.noaa.gov/sshws.shtml) to categorize and convey the impacts of tropical systems based on increasing wind speed.

Category	Sustained Winds
1	74–95 mph 64–82 kt 119–153 km/h
2	96–110 mph 83–95 kt 154–177 km/h
3 (major)	111–129 mph 96–112 kt 178–208 km/h
4 (major)	130–156 mph 113–136 kt 209–251 km/h
5 (major)	157 mph or higher 137 kt or higher 252 km/h or higher

3.3 Weather Warnings Using Relevant Thresholds Agreed With Users/Practitioners

Some NMHS' are now working with other non-weather-related organizations, such as business, security and finance industries, and health and safety organizations, to quantify thresholds and provide targeted warnings based on them. Such thresholds are often developed based on a probability of occurrence for a given hazard, and thereby aid organizations' decision-making and management of activities. Development of criteria to support warnings for an aerodrome is an example of this, with pre-set thresholds being agreed with the customer.

3.4 Weather Warnings with Spatial/Temporal Variation in Thresholds

At this stage in the evolution towards impact-based warnings, the thresholds are no longer predefined and may vary according to the situation in space and time, to represent changing vulnerabilities.

Example from Météo-France

Heat wave thresholds were built in cooperation with the Ministry of Health National Institute for Sanitary Watch, Institut National de Veille Sanitaire (INVS).

For this specific hazard, mortality surveys were conducted and matched with climatological data and led to the design of a BioMeteorological Index, based on a combination of extreme temperatures. Thresholds were then determined according to the results of the surveys and adapted throughout the country, with results varying significantly between the north-western part of the country and the Mediterranean areas in the south east for example.

Temporal variation in thresholds – example of the U.S. Flash Flood Guidance System

As its name suggests this is a service that has been designed to provide "the near-term risk of a flash flood in small streams and basins" and has been developed by the Hydrological Research Center (HRC) in San Diego, California, USA.

The aim of the Flash Flood Guidance System is to provide a diagnostic value (known as *flash flood guidance*) that estimates the amount of rainfall over a given duration within a basin that is required in order to cause flooding within the catchment. The System is designed to update its values and to 'remember' rainfall that has already entered the catchment. In this way, the System takes account of antecedent catchment conditions and can calculate the amount of extra rainfall that is needed in order to produce flooding. When these values are applied in real-time with nowcasts or in a forecasting capacity they can be used to generate a *flash flood warning*.

The System has been used for many years by the U.S. National Weather Service (NWS) and is a good example of a weather warning which is driven by non-fixed, variable rainfall thresholds.

Example of spatial variation in thresholds from DHMZ Croatia

Temperature thresholds for the heat wave hazard for the eight (8) towns in Croatia:

Minimum temperature (°C)			
Osijek	20.1	21.2	22.9
Zagreb	20.2	21.3	22.9
Karlovac	20.0	21.1	22.7
Gospić	17.0	18.0	19.6
Rijeka	22.7	23.7	25.1
Knin	20.5	21.6	23.1
Split	25.8	26.8	28.2
Dubrovnik	25.4	26.3	27.6

Maximum temperature (°C)			
Osijek	35.2	36.7	38.8
Zagreb	33.7	35.1	37.1
Karlovac	34.5	35.9	38.0
Gospić	32.1	33.4	35.4
Rijeka	32.7	33.9	35.5
Knin	35.5	36.9	39.0
Split	33.9	35.1	36.7
Dubrovnik	32.3	33.2	34.7

	Description of thresholds
	Moderate heat wave hazard
	High heat wave hazard
	Extreme high heat wave hazard

3.5 Multi-Hazard Impact-Based Forecast and Warning Services

As the next step in the evolutionary process towards impact forecast and warning services, it is recommended that all NMHSs consider the potential benefits of providing impact-based warnings to the public and to DRCPAs. The fundamental distinction between a general weather warning and an impact-based warning is the inclusion of vulnerability of people, livelihood and property with consideration of the hydrometeorological hazard. That is, the impact of the weather drives the messaging, rather than then the weather itself.

Migrating to an impact-based paradigm involves a number of complex factors.
For example, a forecast of exceeding a certain combination of temperature and relative humidity may trigger a heat warning. However, in an impact-based warning framework, the issuance of a heat warning is driven not only by the hazards themselves, but also by their locations and timing. In some cases NMHSs may wish to offer a different hazard message for an excessive heat event that occurs very early in the season than it would for an identical event during mid-summer, or a forecast flooding event may have much more impact in a highly populated area than in a rural environment (vulnerability factor).

Vulnerability may change with respect to the hazard and will be modulated by the integrity of infrastructure, as well as exposure or sensitivity of populations. Vulnerability itself may change with time as the integrity of infrastructure is bolstered. One example of the latter factor was the implementation of stricter building codes in Florida following Hurricane Andrew in 1992.

Vulnerability assessments, often conducted to develop risk transfer mechanisms such as insurance, may provide the ideal source of data about vulnerability of physical infrastructure. One example of this is the Pacific Catastrophic Risk Assessment and Financing Initiative (PCRAFI), which has systematically collected data at the household level throughout many Pacific Island Countries.

Example from China

An example of an “Impact-Based” Typhoon Warning follows: On 10 August 2013, the violent typhoon “Jutte” developed over the east ocean of the Philippines. On 11 August 2013 “Jutte” had reached super Typhoon strength and made landfall in Guangzhou on 14 August 2013. The Meteorological Administration of GuangDong Province had paid a great deal of attention to “Jutte”, especially from 11 August. As part of their service, the Meteorological Administration forecast the landfall, the precipitation and the wind speed distribution of “Jutte” using the typhoon model. Using this information, the Administration was able to draw a map of impacts using the typhoon disaster impact assessment model. This model divides impacts into seven (7) grades using a colour-coded model. For example, red means “Serious impact” and green means “Slight impact”. These impact maps were offered to the DRCPAs, the transportation department and other Provincial Government Department. These departments arranged the disaster prevention and reduction work according to the impact maps.

3.6 Impact Forecast and Warning Services

For impact forecast and warning services, exposure is explicitly considered along with the hazard and vulnerability. These types of forecasts and warnings are designed to provide detailed information precisely to whom or what is exposed.

In order to provide these types of warnings, NMHSs (or the responsible government agency) must have available detailed vulnerability and exposure information relevant to the hazard and individual entities for whom (or which) the forecasts are provided. Impact Forecast and Warnings Services can only be provided in instances where an NMHS has developed strong partnerships with other relevant agencies, or with user communities.

Critical to a successful warning service, as mentioned earlier, is the development of strong relationships between NMHSs and DRCPAs so that these warnings can be as relevant and useful as possible. In fact, it could be argued, especially given the increasing reliability of numerical

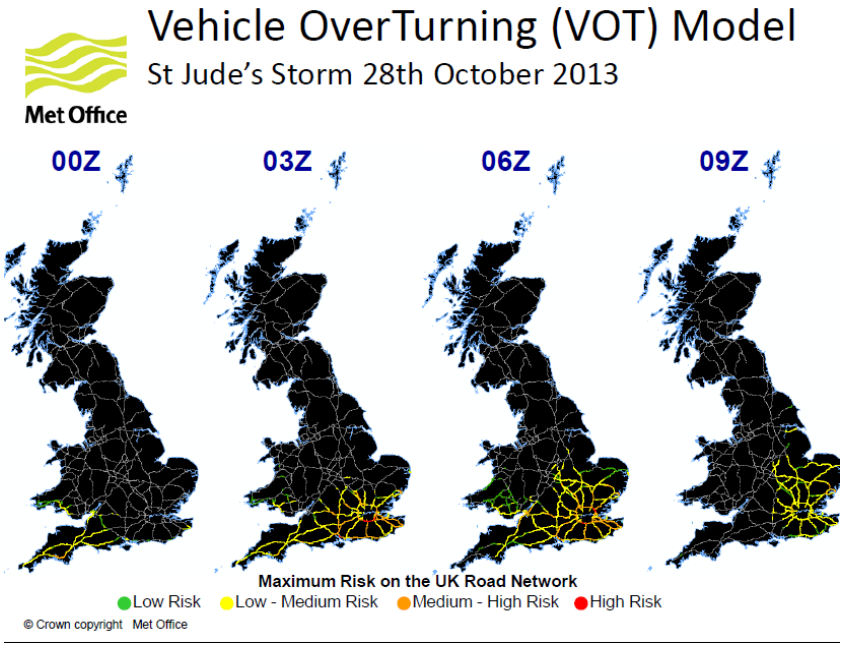
weather prediction and the proliferation of digital forecast databases driven by these models that an increasing proportion of the forecasters' time will need to be dedicated to such collaboration and relationship development.

Thus, NMHSs will need to dedicate resources towards understanding the relationships between the spatial and temporal variations in vulnerability and exposure as they relate to various hazards. This understanding would thereafter be translated into NMHS warning messages that provide meaningful impact information for those they serve.

Example from United Kingdom (the Met Office)

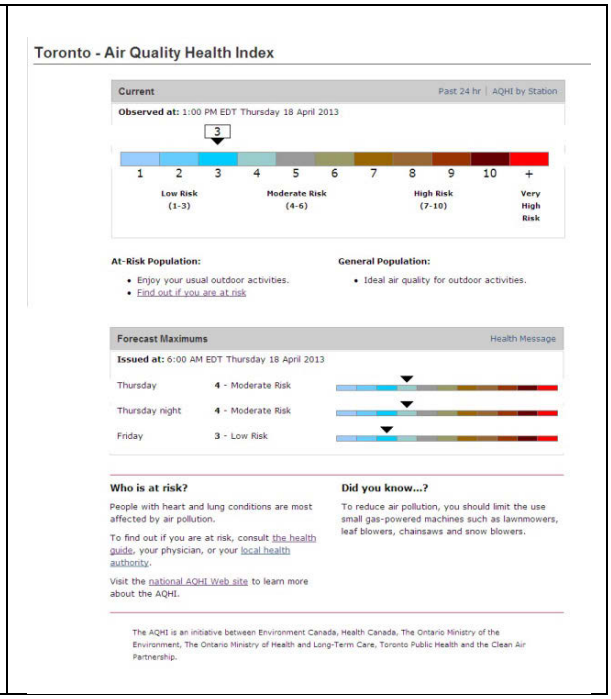
Forecast of a direct impact – in this case the risk of overturning vehicles – due to high winds.

Important to note that the highest impacts (in red) were not at the locations of the expected highest winds.



Example from Environment Canada

Environment Canada has implemented an impact approach to its air quality program (http://weather.gc.ca/airquality/pages/index_e.html). Through partnerships with federal, provincial and municipal environment and health authorities, forecasts and warnings of the 'Air Quality Health Index' (AQHI) are based on identified levels of risks to health and associated potential impacts on people at risk. Call to action statements, to reduce the risk associated with the forecasted air pollution levels, are included in these products.



Having defined above the evolution from general weather forecasts to impact warnings, the table below reviews how worded warnings may evolve using a heavy rain event as an example.

	Evolving warning paradigm using a heavy rain event as an example:	**Factors incorporated**
General Forecast	A cold, windy, wet day tomorrow with spells of very heavy rain expected in the afternoon and evening.	Hazard
Warnings with fixed thresholds	Rainfall accumulations of 30 mm to 40 mm expected tomorrow between 1400 and midnight.	Hazard
Warnings with user-defined thresholds	Heavy rain expected tomorrow afternoon with rainfall intensities of 3 mm/10 mins possible, leading to overflow in the drainage system (note that this type of warning would typically be issued to a municipal authority only).	Hazard, Vulnerability
Warnings with spatial and/or temporal variation in thresholds	Spatial differences: Weather warning – rainfall accumulations of 20 mm to 30 mm expected tomorrow in low-lying areas between 1400 and midnight; with accumulations of 50 mm to 60 mm possible at altitudes above 1,500 m. Temporal differences: Weather warning - rainfall accumulations of 15 mm to 20 mm expected tomorrow afternoon during rush-hour. (Note: the lower threshold at times when the roads will be very busy).	Hazard, Vulnerability

Evolving warning paradigm using a heavy rain event as an example:		Factors incorporated
Impact-based warning	Rainfall accumulations of 20 mm to 30 mm expected tomorrow between 1400 and midnight; resulting in possible road closures due to flooding across the south-east. (Note the subtle but important distinction between the impact-based warning and the threshold warning described above. The distinction is that the threshold-based warnings just specified generalized flooding; the impact-based warning provided specific mention of an impact, in this case road closures).	Hazard, Vulnerability
Impact Warning	Expect journey times on the A111 likely to be lengthened by an hour because of significant traffic disruption in the south-east tomorrow afternoon due to localized flooding which is expected to follow a heavy rain event.	Hazard, Vulnerability, Exposure

3.7 Schematics Depicting Conceptual and Operational Applications of Impact Forecasting

Before moving towards impact-based or impact forecasting, it is important that an NMHS understand the possible conceptual models that underlie the paradigm, as well as the operational approaches currently in use.

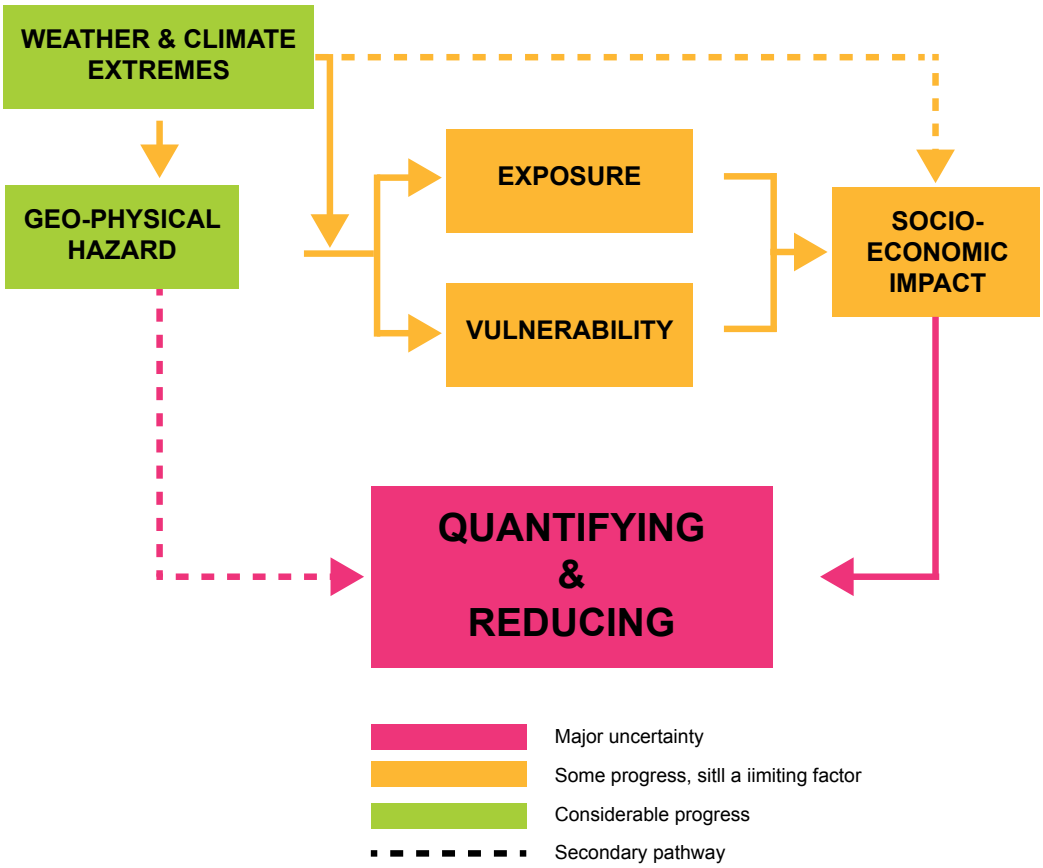
Conceptual Paradigm

The figure below represents the relationship among the key elements of an impact forecast system. There are three (3) possible pathways towards estimating an assessment of impact for a given hydrometeorological hazard.

1. The solid arrows represent the modelling approach where each element is explicitly calculated. To do this requires detailed data on vulnerability and exposure, which may need to be acquired from other agencies.

2. The dotted orange arrow relates a more subjective approach where qualitative information is collected from expert partners. This information represents the sum of their experience and allows the estimation of impact directly from the magnitude of the hazard.

3. The red arrows represent a more traditional approach whereby the magnitude of the likely impact is related directly to the magnitude of the meteorological hazard. This approach can help in identifying and reducing risk, but takes no explicit account of exposure or vulnerability; just the magnitude of the meteorological hazard itself.



Operational Approach:

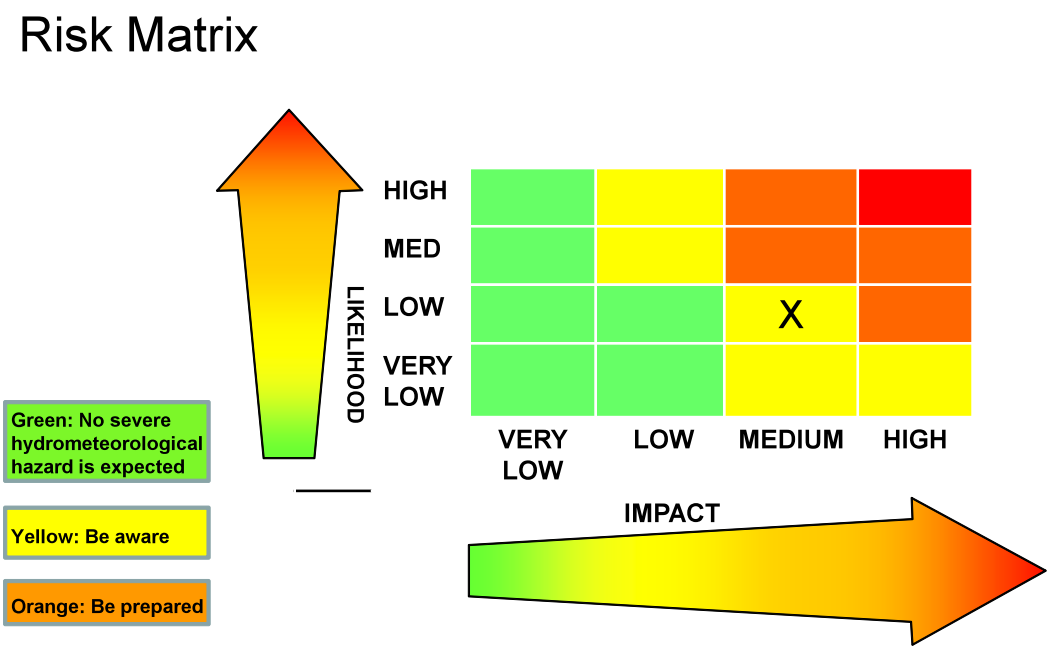
It is recommended that NMHSs work with their DRCPAs to identify how the likelihood of expected hazard and its potential severity can be considered in tandem to create a "Risk Matrix". The diagram below illustrates a suggested operational application of the impact warning concept, combining impact with likelihood to create a "Risk Matrix", expressing risk through a simple "traffic-light" colour scheme. Recall here that impact incorporates an assessment of vulnerability and exposure.

In contrast to the traditional threshold-based or "yes/no" weather warning system, the approach exemplified by the matrix below facilitates the following:

1. A consistent means for the early expression of potential impact, well in advance of a significant hydrometeorological event.

2. A means to progressively express changing expectations of risk as a function of varying exposure, vulnerability and hydrometeorological likelihood.

This approach is used by the Met Office and a number of other European NMHSs who contribute to the Meteoalarm system (www.meteoalarm.eu).



Assign a colour to the warning which is a combination of potential impact and likelihood
(source: Met Office)

3.8 Benefits of an Impact warning service

The creation of impact warnings and the systems supporting them are based on close coordination between NMHSs and different organizations, including DRCPAs. The benefits of these partnerships are multiple and ensure that the sharing of knowledge and expertise render the impact messaging relevant to the users of this information. Specifically, the process of developing an impact framework results in the following:

- Improved planning for different scenarios based on different thresholds, impacts or combinations of impacts occurring;
- Better contingency planning (best, reasonable worst-case and most likely outcomes);
- Information about level of confidence in the forecast which would convey additional information for better decision-making (a more informed risk assessment);
- New information to facilitate wider social benefits;
- The basis for post-event analysis of natural hazard impacts to assist in planning, response and mitigation of impacts;
- A comprehensive and coordinated process to address disaster response and preparedness;
- Common situational awareness

Impact forecasts and warnings relay a message of greater relevance to enable those at risk to take appropriate actions in order to mitigate the overall adverse effects of hydrometeorological hazards.

CHAPTER 4: RECOMMENDED ELEMENTS IN THE DEVELOPMENT OF IMPACT FORECAST AND WARNING SERVICES

In order to realize the benefits of impact forecast and warning services, as described in Chapter 3, NMHSs will need to address the development of systems and of their staff in partnerships with many other agencies. The following describes some of these elements.

4.1 Partnerships

NMHSs have the expertise and capacity to deal with hydrometeorological forecasting and warnings. However, meteorologists, in the course of their normal work, will not normally learn about vulnerabilities, exposure and emergency disaster management. Therefore, collaboration with, and support from, their governments, international bodies, scientific institutions and local communities are needed. This should result in better risk assessments, improved monitoring, early warning and enhanced overall response to hazards and disasters.

Key partnerships need to be established with those organizations that have direct responsibility for the safety and security of populations. Among these, DRCPAs are key partners and users. They can help evaluate vulnerabilities, potential impacts and mitigation actions necessary to counter impacts. Depending on national public policies, these agencies could be in the position to lead the impact-based warnings development process, even if these are initiated and supported by the NMHS.

The *Guidelines for Creating a Memorandum of Understanding and a Standard Operating Procedure between a National Meteorological or Hydrometeorological Service and a Partner Agency* (WMO-No. 1099, PWS-26), provides examples that identify certain key steps in developing these partnerships and agreements. To enable the sharing of data, good practices and support among NMHSs and relevant partners, a common and collective understanding of the decision-making processes involved in disaster reduction, from the first warning of the event to the response and recovery, must be established.

In developing partnerships with potential agencies, the following should be considered:

- Determine those government entities and other stakeholders that should support, or already support, the need for impact forecasting;
- Define clear governance between parties including steering committees and advisory groups;
- Ensure agreed legal framework is put into place to facilitate Intellectual Property sharing and exchange of good practice;
- Establish programme management to include roles and responsibilities for development, implementation, delivery, and verification of impact-based products and services;
- Develop a communications strategy to define expected services, the respective role(s) of parties (including local populations), and outreach activities;
- Agree upon a strategy to verify, evaluate and provide Quality Management System (QMS) and assurance of products and services;
- Assess whether international cooperation is required.

In 2011, the **Natural Hazards Partnership** (NHP) was created in the United Kingdom to improve the coherence and quality of hazard management across government, and the planning, preparation, warning and response to natural hazards. The NHP is a partnership of key United Kingdom organizations that play a leading role in natural hazard science and research.

The vision of the NHP is to deliver coordinated assessments, research and advice on natural hazards for Governments and resilience communities across the United Kingdom.

4.2 Development of Information and Services

Once NMHSs partnerships have been established, the next step is to leverage these relationships to jointly design and develop an impact-focused framework. This links historical hydrometeorological events with information about vulnerability, exposure and recorded impacts. It is recommended that the NMHS contribution rely upon historical data, and climate data available in their climate services units. The resulting impact-based criteria should be shared and made readily accessible by all parties.

These criteria will be determined from a variety of factors including hazard, vulnerability and exposure information based on specific weather criteria, risk assessments and maps, and socio-economic data. Also required is a means to monitor and react to changing situations via a number of sources, potentially including social media, to ensure that up-to-date warning information reaches all users.

A holistic approach to observing, modelling and predicting severe weather and the consequent natural hazards, through to their impacts, needs to be developed. This will require a multi-disciplinary, highly integrated, and directed scientific endeavour to translate natural hazard risk into impact services and a validation process to assess service benefits and performance bespoke to users. Observing strategies may need to be revisited so that they can capture, exchange and integrate impact observations into forecasting systems. This will bring twofold benefits; firstly to validate impacts and their consequences (this might be achieved through crowd sourcing technologies) and secondly, to provide the initial conditions that are needed to drive downstream impact models. The list of observations could be far-reaching and diverse involving social media, unconventional observations captured from mobiles and other technologies (e.g. transport), and webcams, etc.

This aspect will require further consideration since to genuinely share impact observations requires an ability to integrate, categorize and manage third party observations in a manner not done heretofore; establishing agreed data formats and data standards, developing the principles through

which data can be exchanged and shared, crafting systems which can work together, and reaching joint agreements to management foreground (the new intellectual property which is developed through a relationship between two agencies collaborating together) and background (the intellectual property developed independently by each individual agency prior to entering into the collaboration relationship) IPR.

Services will then be developed to meet user requirements, keeping in mind that the ultimate purpose is to reduce the adverse impacts of hydrometeorological events. As a consequence, requirements such as timeliness, clarity of message, and update schedules will be as important as the scientific or technical requirements which meteorologists are more familiar with.

4.3 Functional Requirements for Impact-based Forecasting and Warnings

This section introduces technical and functional features required in the development of the collaborative system supporting forecasts and warnings that focus on impacts.

Technical features to be considered are:

- data and metadata management including acquisition, harmonization, interoperability and sharing strategies;
- implementation of relevant technical tools (databases, models, information);
- dissemination platforms, protocols and formats such as XML/CAP, colour-coded graphics, GIS layers, etc.;
- continuity of operations;
- archiving.

Operating features within and between cooperating agencies should be established to specify:

- operational workflow between partners;
- dissemination processes, communication and interaction with media;
- backup means and contingency procedures;
- real-time monitoring of impacts and feedback;
- crisis management arrangements (escalation process, crisis communication);
- post event assessment.

4.4 Developing the Capacity of NMHS Staff and Partners

As has been identified in the previous sections, the development of impact-based and impact forecasting entails the gathering of requirements, the establishment of infrastructure, technical development, operating and communication processes and the identification of roles and responsibilities of all partners involved. Although a significant amount of effort and work will be required to address these aspects, success in the development and later implementation of this initiative will be primarily based on the human resources within organizations. The evolution towards impact-based and impact forecasting will require a change in culture for many NMHSs as well as developments in the relationships they have with existing partners.

In order that staff address and adopt this new endeavour, organizations must ensure that they provide the means to develop the required set of skills and competencies, as well as the knowledge of how partners mutually use information to deliver on their mandates. Understanding hydrometeorological concepts is part of the picture. However understanding how these are integrated within partners' decision-making is essential. The following need to be considered:

1. Identifying required competencies and skills

Once roles and responsibilities are established within organizations, a professional competency framework must be determined with respect to both functional and behaviour competencies such as communication (reference the WMO/PWS competencies).

2. Cross-training on specific requirements and procedures

NMHS staff and those of partners should have an understanding of common features of the system, and potential limits in tools and interpretation in order to adequately interpret information and data that will be exchanged. Simulation exercises and collaborative workshops are recommended to achieve this training.

3. Educating users on how to use impact forecast information

Media, public and specific users must be informed as to how warning information produced can be best used to mitigate impacts.

4.5 Validation

Validation is viewed here in the usual Quality Management (QM) perspective with the aim of bringing evidence of what is working well and what requires improvement within a system.

This is not only a matter of objective verification and computation of scores as NMHSs customarily create (verification of NWP, for example), but assessing the total performance of an impact-based or impact forecast and warning system.

The validation process should be organized and agreed upon during the partnership-building phase as it is crucial that such assessment address the overall system, and is performed in a collaborative manner.

Success of an impact-based or impact forecast validation process will depend upon the capacity of NMHSs and partners to gather, store and share as much information as possible on the actual impacts of a hydrometeorological event, in addition to simulation exercises that help validate procedures.

It is strongly recommended that:

- impact-based monitoring tools, capabilities, and networks to verify impact-based forecasts and warnings are developed;
- evaluation is performed systematically for significant events (to be defined and agreed upon, see section 4.1 “Partnerships)”;
- all those involved during the event participate in evaluation of their contribution and in the feedback process with respect to achieving their mandate;
- regular meetings be held with stakeholders to establish a comprehensive analysis of the events from warning to actions taken, and consequences from the user/stakeholder point of view;
- improvement is planned, trialled and operationalized according to evaluations and feedback by the users;
- success stories are used as good practices examples and proof of concept among partners, stakeholders and with the public.

CHAPTER 5: OVERARCHING MANAGEMENT APPROACH FOR EVOLVING TOWARDS IMPACT-BASED AND IMPACT FORECAST AND WARNING SERVICES

Implementing impact-based and impact forecast and warning services requires significant behavioural changes of staff within NMHSs' and their partners. One recommended approach is to adopt a change management framework policy that enables a smooth transition from weather forecasting to impact forecasting. This chapter provides a systematic approach for how such a framework could be applied, based on a five step approach "Awareness, Desire, Knowledge, Application and Reinforcement", the so-called "ADKAR" model (Hiatt, 2006).

A "Change Management Model applied to Impact Forecasting"

Stage 1. Awareness: Secure consent

- Initiate discussion to raise awareness of the issues and need for impact-based and/or impact forecast and warning services within NMHS and between NMHS and DRCPAs or equivalent government department (see Section 4.1);
- Extend consultations among stakeholders, including government agencies and academia;
- Coordinate with these agencies to raise the relevance of impact-based and impact forecast and warning services, and its benefits;
- Agree initial communications and messaging for internal and external use;
- Forge consensus and support the need to proceed to the next step (Stage 2).

Stage 2. Desire: Endorsement and Assessment

- Bring together partners and experts, through a workshop, preferably hosted at a neutral site to:
  - Introduce the benefits of impact-based and impact forecasting;
  - Analyse and review the issues and gaps;
  - Find what each partner wants from the partnership, and does not want;
  - Reach a common ground on the proposed level of impact forecasting required from simpler multi-hazard impact-based forecasts and warnings (see Section 3.5) to user-specific, tailored impact forecasts and warnings (see Section 3.6);
  - Develop a Strength, Weakness, Opportunities, Threats (SWOT) analysis to identify the capacity and capabilities of each partner; for example, the capacity to respond to warnings by DRCPAs.
- Explore, prioritize and rate those hazards and impacts that are of importance in the particular country or region;
- Determine current status of vulnerability assessments to the prioritized meteorological hazards; identify gaps in knowledge, and develop a plan to address these gaps;
- Develop hazard-specific, time-dependent exposure information for human activities;
- Innovate, using the science-to-service ethos, to identify new, to enhance, or to retire existing impact-based and impact services.

Stage 3. Knowledge: Planning and Integration

- Develop a Memorandum of Understanding (MOU) (see section 4.1);
- Introduce project management and control to:
  - Develop an operating plan with an agreed vision, mission, objectives, milestones, funding model and financing trials, benefits realization plan, risk register, etc.;

  - Create a legal framework for intellectual property and data exchange/usage etc.;
  - Collect, manage, categorize, store and exploit data;
  - Establish working groups, chairs and associated Terms of Reference (TOR);
  - Build trials to develop new services, or to enhance or retire existing ones;
  - Ensure minute taking and recording;
  - Communicate and engage with stakeholders;
- Set up institutional framework, as required;
- Train providers and users of services based around a competencies framework;
- Formulate monitoring and evaluation tools to assess service progress and improvements.

Stage 4. Apply and Implement

- Implement the impact-based and/or impact forecast and warning services;
- Monitor implementation and communicate with users;
- Prepare regular updates between partners and users;
  - Newsletters/news group/website/meetings;
- Create a user group of customers and establish terms of agreement;
  - Establish feedback protocols and Quality Assurance (QA) with the user group so that during trials the partnership can evaluate and verify the usefulness and relevance of new services;
- Create a core stakeholder and funder partner group to challenge, support and assist in the building and implementation of a sustainable business/funding model;
- Develop a branding and marketing strategy (attribution to partners);
- Conduct post-event evaluation and promote benefits;
- Continue to refine protocols and services;
- Challenge science to develop impact, risk and social science research;
- Challenge technology to deliver application layers, e.g., GIS tools, to mash data and delivery channels to disseminate information;
- Develop impact-based monitoring capabilities and databases to capture impact information.

Stage 5. Reinforcement

- Operationalize and implement those services trialled which were cost effective and delivered the most value to customers;
- Operate a QMS;
- Enhance partner and user coordination;
- Sustain resources and funding to enhance services;
- Provide continuous training and mentoring;
- Focus on continuous improvement;
- Consider expanding partnerships.

Resolution 2 (CBS-Ext.(2014))

ESTABLISHMENT OF AN INTERCOMMISSION TASK TEAM TO REVIEW PROCESSES FOR PRIORITIZING OF DATA STREAMS AND CACHE CONTENT

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 1 (Cg-XVI) – World Weather Watch Programme for 2012–2015,

(2) The *Manual on the WMO Information System* (WMO-No 1060),

Noting further:

(1) That the capacity of the WMO Information System (WIS) Core Network is a limited resource,

(2) The requirement for Global Information System Centres (GISCs) to ensure the effective operation of the communication systems and services,

Recognizing:

(1) The increasing requirement for the global exchange of all types of environmental data in addition to the established ongoing exchange of meteorological data and products under the auspices of the World Weather Watch and other WMO Programmes, including the Global Framework for Climate Services,

(2) That the addition of new data or products to the WIS Core Network has an impact on all GISCs that have to ensure their capacity is sufficient to handle data and product exchange,

(3) That GISCs have already established a multilateral collaboration forum through the Expert Team on WMO Information System Centres/Task Team on GISCs,

(4) That, although GISCs are responsible for their access to and capacity management of the WIS Core Network, the WMO constituent bodies are ultimately responsible for the content of and capacity requirements for the WMO Information System,

(5) That information that is required to be exchanged between all GISCs is flagged in the discovery metadata by the keyword GlobalExchange,

Decides that there is a need for a formal mechanism for deciding what should be designated for global exchange, and thus held in the cache, and for determining the transmission priority;

Requests the Implementation Coordination Team on Information Systems and Services to establish an ad hoc intercommission task team to work with GISCs to recommend a process for making decisions affecting the capacity management of WIS networks, in particular the WIS Core Network and the GISC cache; the task team should also consider the need for this decision-making process to resolve issues that the collaborative mechanisms established by GISCs are unable to resolve;

Requests the Secretary-General to make available the necessary resources to support the work of this ad hoc intercommission task team.

Resolution 3 (CBS-Ext.(2014))

REGULATION OF CLIMATE DATA MANAGEMENT SYSTEM SPECIFICATIONS THROUGH THE WMO INFORMATION SYSTEM

THE COMMISSION FOR BASIC SYSTEMS,

Noting that the WMO Information System (WIS) provides an overarching approach to data and information management for all WMO and related international programmes,

Noting further:

(1) That the *Manual on the WMO Information System* (WMO-No. 1060), paragraph 3.1, states: "An ongoing process for understanding user requirements … All supported programmes and technical commissions shall participate in this process, which shall be part of general WMO requirement reviews",

(2) That the functional scope and physical sizing of WIS shall be determined through an ongoing process for understanding user requirements,

(3) That the Manual and the *Guide to the WMO Information System* (WMO-No. 1061) are designed to ensure adequate uniformity and standardization in the data, information and communication practices, procedures and specifications employed among Members in the operation of WIS,

Considering:

(1) The recommendation made by the Commission for Climatology (CCl) at its sixteenth session that the Commission for Basic Systems work closely with it in order to identify the relevant parts of the CCl Climate Data Management System (CDMS) Specifications publication for possible inclusion in the WMO Technical Regulations,

(2) That the Manual is Annex VII to the WMO Technical Regulations,

Decides to collaborate with the Commission for Climatology through ad hoc expert meetings to make a proposal for regulating CDMS specifications through WIS regulation and references, including the *Manual on the WMO Information System* and the *Guide to the WMO Information System*;

Requests the Secretary-General to provide support to the collaboration of the Commission for Basic Systems and the Commission for Climatology on the regulation of CDMS specifications.

RECOMMENDATIONS ADOPTED BY THE SESSION

Recommendation 1 (CBS-Ext.(2014))

COMPETENCY FRAMEWORK FOR PUBLIC WEATHER SERVICES FORECASTERS AND ADVISERS

THE COMMISSION FOR BASIC SYSTEMS,

Noting the recommendation of the Sixteenth World Meteorological Congress that all technical commissions make the definition of competence requirements for the core job-tasks in meteorology and hydrology a high-priority activity and incorporate this task into their current work programmes,

Noting further:

(1) That Sixteenth Congress requested that the technical commissions follow the model developed by the Commission for Aeronautical Meteorology in providing top-level competence requirements,

(2) That the Commission for Basic Systems at its fifteenth session decided to establish a Competency Framework for Public Weather Services Forecasters and Advisers,

(3) That this Competency Framework will inform the education and training of forecasters,

(4) That this Competency Framework was developed in close consultation with the Executive Council Panel of Experts on Education and Training and will inform the content of WMO education and training courses, workshops and seminars,

Considering the development by the Open Programme Area Group on Public Weather Services of a Competency Framework that describes the basic forecaster competencies, and then adds on those skills and knowledge that are required for effective service delivery and liaison with users, as contained in sections 1 to 5 of the annex to the present recommendation,

Recommends that this Competency Framework, as contained in the annex to the present recommendation, be endorsed, that it be established as a WMO Recommended Practice, and that it be included in the *Guide to Public Weather Services Practices* (WMO-No. 834);

Requests the Executive Council Panel of Experts on Education and Training to cooperate with the Commission and, with assistance from the Secretariat, to prepare a proposal for amendment of the *Technical Regulations* (WMO-No. 49) to incorporate these competencies as Recommended Practice for the Public Weather Services forecaster/adviser;

Urges Members to make use of this Competency Framework in maintaining and improving the skills and knowledge of staff engaged in the production and delivery of Public Weather Services products and services.

Annex to Recommendation 1 (CBS-Ext.(2014))

COMPETENCY FRAMEWORK FOR PUBLIC WEATHER SERVICES FORECASTERS AND ADVISERS

1. FUNDAMENTAL WMO COMPETENCY REQUIREMENTS FOR A PWS FORECASTER

The competency requirements for the work of an operational PWS forecaster[1] can be divided into five top level competencies. Taking into consideration the following:

(a) The nationally-defined PWS areas of responsibility;

(b) Meteorological and hydrological impacts on society;

(c) Meteorological and hydrological user requirements, local procedures and priorities.

A PWS Forecaster should have successfully completed the BIP-M[2] (as defined in the revised WMO-No 49, Volume I) and, in taking into account conditions a to c, should be able to perform the work indicated in the five top level competencies below:

(1) Analyse and monitor continually the evolving meteorological and/or hydrological situation;

(2) Forecast meteorological and hydrological phenomena and parameters;

(3) Warn of hazardous phenomena;

(4) Ensure the quality of meteorological and hydrological information and services; and

(5) Communicate meteorological and hydrological information to internal and external users.

Each of these top-level competencies is expanded, below, into second-level competencies that are expressed and structured in such a manner as to facilitate the clear application of an assessment procedure. Each is also associated with a range of background knowledge and skills, some of which may not be particular to meteorology and/or hydrology, but which are nonetheless essential in the discharge of a forecaster's duties.

1. Analyse and monitor continually the evolving meteorological and/or hydrological situation

Competency Description: Observations and forecasts of weather parameters and significant weather phenomena are continuously monitored to determine the need for issuance, cancellation or amendment/update of forecasts and warnings according to documented thresholds and regulations.

Performance Criteria:

(a) Analyse and interpret data to identify weather features pertinent to the area of forecast responsibility;

(b) Monitor weather parameters and evolving significant weather phenomena and validate current forecasts and warnings based on these parameters;

(c) Evaluate the need for amendments to forecasts and updates of warnings against documented criteria and thresholds.

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[1] A PWS forecaster is defined as a forecaster responsible for the preparation and delivery of public weather forecasts and warnings

[2] BIP-M: Basic Instruction Package for Meteorologists

1.1 Background knowledge and skills

(a) An understanding of the key elements of synoptic and mesoscale meteorology, dynamical, and physical meteorology, and core analytical/diagnostic skills to the level of a BIP-M;

(b) Application of the theory, methods and practices of meteorological and/or hydrological analysis and diagnosis;

(c) The ability to visualize/conceptualize meteorological and/or hydrological information in multiple dimensions (spatial, temporal);

(d) The appreciation of the influence of topography, land cover, and (if relevant) bodies of water and/or snow fields on local meteorology;

(e) Interpretation in-situ and remote-sensed observations and data;

(f) Understanding of the characteristics of meteorological and hydrological sensors and instruments; and

(g) Familiarity with the acquisition, processing and assimilation of meteorological and hydrological data, including quality control.

2. Forecast meteorological and hydrological phenomena and parameters

Competency Description: Forecasts of meteorological parameters and phenomena are prepared and issued in accordance with documented requirements, priorities and deadlines.

Performance Criteria:

(a) Forecast weather phenomena and parameters as required, including forecast uncertainties and using appropriate tools;

(b) Ensure that forecasts are prepared and issued in accordance with national practices, relevant codes and technical regulations on content, accuracy and timeliness;

(c) Make every effort to ensure that forecasts of weather parameters and phenomena are consistent (spatially and temporally) across boundaries of the area of responsibility as far as practicable, whilst maintaining meteorological integrity. Monitor forecasts/warnings issued for other regions, and liaise with adjacent regions as required.

2.1 Background knowledge and skills

(a) Core diagnostic and prognostic skills to a BIP-M level;

(b) Demonstrates a knowledge of the methods used in Numerical Weather Prediction (NWP), including EPS where used, and other forecast tools;

(c) Knowledge of the strengths and limitations of the NWP models used in the forecast office, and forecast adjustments required to accommodate these;

(d) Critical comparison of a variety of forecast models, interpretation of observational data, and climatological data and integration of this information to make a reasoned estimation of the most likely evolution of the weather, of alternative evolutions, and the uncertainties associated with each;

(e) Interpretation of model outputs at different time ranges;

(f) Sound judgement and flexibility in determining which observational, model and contextual information is most relevant in a wide variety of circumstances;

(g) Knowledge of weather impact on the user.

3. Warn of hazardous weather

Competency Description: Warnings are issued in a timely manner when hazardous conditions are expected to occur, or when parameters are expected to reach documented threshold values, and updated or cancelled according to documented warning criteria.

Performance Criteria:

(a) Forecast hazardous weather phenomena, including spatial extent, onset/cessation, duration, intensity and temporal variations;

(b) Ensure that warnings are prepared and issued in accordance with national thresholds for hazardous weather, national formats, practices, codes and technical regulations on content, accuracy and timeliness;

(c) Make every effort to ensure that warnings of hazardous weather phenomena are consistent (spatially and temporally) across boundaries of the area of responsibility as far as practicable, whilst maintaining meteorological integrity. Monitor forecasts/warnings issued for other regions, and liaise with adjacent regions as required;

(d) Knowledge of the consequences of warnings on users decisions.

3.1 Background knowledge and skill

(a) Knowledge of the specific product preparation and dissemination systems used in the forecast office;

(b) Knowledge of the policies, procedures and criteria for issuing warnings.

4. Ensure the quality of meteorological and hydrological information and services

Competence description: The quality of meteorological and hydrological forecasts, warnings and related products is maintained by the application of approved quality management processes.

Performance Criteria:

(a) Apply the organization's quality management system and procedures;

(b) Organize the work required on each shift to ensure that forecasts and other output are issued in good time according to agreed policies and procedures;

(c) Validate meteorological and hydrological data, products, forecasts and warnings (timeliness, completeness, accuracy);

(d) Assess the impacts of known error characteristics (bias, achievable accuracy of observations and sensing methods);

(e) Monitor the functioning of operational systems and take contingency actions when necessary;

(f) Contribute to the preparation and maintenance of operational manuals.

4.1 Background knowledge and skills

(a) Has the ability to respond to changing work patterns and demand, ensuring continuity of service to users;

(b) Necessary time and work flow management skills;

(c) An appreciation of the varied technical knowledge and methodologies necessary across a multi-disciplinary team;

(d) The ability to respond to changing user requirements, to embrace innovative techniques and technology; and

(e) The ability to learn from and apply past experience to improve the quality of forecasts and warnings.

5. Communicate meteorological and hydrological information to internal and external users

Competency Description: User requirements are fully understood and are addressed by communicating concise and complete forecasts/warnings in a manner that can be clearly understood by the users.

Performance Criteria:

(a) Ensure that all forecasts/warnings are disseminated through the authorized communication means and channels to designated user groups as specified in relevant standard operating procedures;

(b) Explain meteorological/hydrological data and information, including uncertainties where required, and deliver briefings and provide consultation to meet specific user needs as required.

5.1 Background knowledge and skills

(a) Skills in the presentation of forecast and warning information to the public across all relevant media, including impact information as required;

(b) Knowledge of protocols for presenting warning information to emergency management partners, including information on likely impacts and mitigation activities if relevant;

(c) An awareness of user's needs for, and use of, meteorological and/or hydrological information;

(d) Awareness of the application of meteorology and hydrology to human activities and specific users.

2. COMPETENCY REQUIREMENTS FOR WEATHER BROADCASTERS AND COMMUNICATORS

These competency requirements are for PWS forecasters who specialize in media work and routinely present weather information on radio or television, or prepare material for weather websites. They build upon, and should be read in conjunction with, the fundamental WMO competency requirements for a weather forecaster, although it is recognized that some people engaged in weather broadcasting may not come from a forecasting background.

There are three top-level competencies for the work of weather broadcasters, which are as follows:

(a) Oral, written and graphical communication via media;

(b) Use of appropriate tools and systems for the delivery of meteorological and, where appropriate, hydrological information to end-users;

(c) Self-management and team-working within a media environment.

Each of these areas is expanded below into second-level competencies that are expressed and structured in a manner that facilitates the clear application of an assessment procedure. Not all of these second-level competencies will be relevant to each weather broadcaster; the individual context of each weather broadcaster will need to be considered when establishing relevancy.

1. Oral, Written and Graphical Communication

(a) Shows an awareness of the range of users reached through media forecasts;

(b) Demonstrates an understanding of the likely impact of upcoming weather on users and their activities;

(c) Can identify the key points in a weather story and develop these into a coherent narrative or presentation;

(d) Is capable of articulating the weather story in clear and natural language using correct grammar, and achieving a well-paced delivery of information during weather broadcasts;

(e) Can prepare effective weather graphics that visually communicate the weather story;

(f) Is able to communicate the concept of forecast uncertainty to viewers and listeners in terms they can understand;

(g) Presents warnings of meteorological and hydrological hazards clearly and effectively, including information on possible mitigating actions where appropriate;

(h) Demonstrates an understanding of the working environment of journalists and other media professionals;

(i) Creates and delivers presentations on meteorological and hydrological topics to external agencies and to the public;

(j) Is capable of preparing and delivering educational material to a wide range of audience, from children to fellow-professionals.

2. Effective use of tools and systems

(a) Exhibits a working knowledge and understanding of the function and, where appropriate, operation of the different technological elements (PCs, servers, mixers, amplifiers, cameras, etc.) commonly employed in weather broadcasting;

(b) Displays a working knowledge of the weather graphics software packages used to prepare weather bulletins, and an ability to exploit this knowledge effectively;

(c) Applies routine production protocols appropriate to the service provision environment;

(d) Designs and incorporates new graphic elements into a weather bulletin while maintaining alignment with broader editorial policies.

3. Self-management and team-working

(a) Has knowledge of the editorial policy applied to weather broadcasting, and is capable of developing and proposing revisions to such policies in response to changing circumstances, both meteorological and otherwise;

(b) Delivers weather broadcasts reliably and on-time in accordance with broadcast schedules;

(c) Implements, where relevant, the “Single Official Voice” policy in respect to warnings of severe weather and other public safety messages;

(d) Presents an appearance which enhances the brand value both of the NMHS and the broadcaster, and does not detract from, or conflict with, the proper tone of the weather message;

(e) Exhibits the confidence to express personality in a manner that facilitates the authoritative delivery of the weather forecast;

(f) Contributes to the promotion of weather presentation services to broadcast companies, and articulates the benefits of good weather broadcasting practices both within the NMHS, and to non-meteorological broadcast management;

(g) Does not allow commercial sponsorship to unduly obscure, or conflict with, the weather message;

(h) Critiques their own and other broadcasters performances in a constructive and positive manner;

(i) Mentors junior colleagues and provides support and advice as required.

3. COMPETENCY REQUIREMENTS FOR PWS ADVISERS ENGAGED IN USER INTERACTION, MEDIA LIAISON AND OUTREACH ACTIVITIES

These competency requirements are for PWS Advisers who specialize in media liaison work and in education / outreach. They build upon, and should be read in conjunction with, the fundamental WMO competency requirements for a PWS forecaster, although it is recognized that some people engaged in media liaison and outreach on behalf of NMHSs may not come from a forecasting background.

There are four top-level competencies for the work of media liaison and outreach, which are as follows:

(a) Oral and written communication;

(b) Use of appropriate tools and systems required for the delivery of meteorological and hydrological information to end-users;

(c) User interaction;

(d) Self-management and team-working in a media environment.

Each of these areas is expanded below into second-level competencies that are expressed and structured in a manner that facilitates the clear application of an assessment procedure. Not all of these second-level competencies will be relevant to each PWS Adviser; the individual context of each PWS Adviser will need to be considered when establishing relevancy.

1. Oral and Written Communication

(a) Exhibits an awareness of the range of users reached through media;

(b) Demonstrates an understanding of the likely impact of upcoming weather on users and their activities;

(c) Is capable of presenting warnings of meteorological and hydrological hazards clearly and effectively including information on possible mitigating actions where appropriate;

(d) Demonstrates an understanding of the working environment of journalists and other media professionals;

(e) Is able to communicate in an effective and timely manner;

(f) Exhibits an ability to work closely with colleagues responsible for communication and public affairs in the NMHS and assists in preparing press releases or interviews as required;

(g) Can prepare and deliver educational material in clear and appropriate language to a wide range of audience, from children to fellow-professionals;

(h) Demonstrates an appropriate understanding of the scope and limitations of forecasts and warnings, and communicates appropriate levels of confidence and uncertainty effectively.

2. Use of appropriate tools and systems required for delivery of meteorological and hydrological information to end-users

(a) Demonstrates a knowledge of the channels used to communicate weather and related information, and an ability to exploit this knowledge effectively;

(b) Demonstrates knowledge of the routine production protocols appropriate to their own service provision environment.

3. User interaction

(a) Can provide guidance to users to assist them in developing a proper integration of meteorological and hydrological information in decision-making;

(b) Has the ability to provide advice and comments on the development of meteorological and hydrological services and products in accordance with user requirements;

(c) Demonstrates an ability to advise users on of the scope and limitations of forecasts and warnings and their application to effective decision-making, appropriately aligning uncertainty and confidence levels with scientific guidance.

4. Self-management and team-working

(a) Can work in a cooperative fashion with colleagues from an NMHS, with representatives of users and, where appropriate, with journalists and other media staff;

(b) Presents a professional appearance which enhances the brand value of the NMHS;

(c) Demonstrates appropriate levels of trust, integrity, consideration of user needs, timeliness, confidentiality and discretion in all work activities;

(d) Is capable of ensuring consistency of message both across the NMHS and with stakeholders, both internal and external;

(e) Mentors junior colleagues and provides support and advice as required.

4. COMPETENCY REQUIREMENTS FOR A DISASTER PREVENTION AND MITIGATION WEATHER ADVISER

These competency requirements are for weather advisers who work in the area of Disaster Prevention and Mitigation (DPM) and engagement with the Emergency Management (EM) community. They build upon, and should be read in conjunction with, the fundamental WMO competency requirements for a PWS forecaster, although it is recognized that some people engaged in liaison and outreach in EM on behalf of NMHSs may not come from a forecasting background. In such cases, the DPM Adviser needs to work closely with the PWS forecaster to develop the products and services indicated in the following sections. A DPM Adviser, taking into consideration the conditions (a) to (c) below:

(a) The nationally-defined PWS areas of responsibility;

(b) Meteorological and hydrological impacts on society;

(c) Meteorological and hydrological societal requirements, local procedures and priorities.

They should be able to perform the work (in close association with the PWS forecaster if needs be) indicated in the five top level competencies below:

1. Communicate warnings and associated information, including uncertainties and confidence levels, to users;

2. Develop products, procedures and services to meet user needs;

3. Develop and manage DPM stakeholder relationships;

4. Promote and implement impact assessments and community outreach; and

5. Ensure the quality of information, services and procedures.

Each of these top-level competencies is expanded below into second-level competencies that are expressed and structured in such a manner as to facilitate the clear application of an assessment procedure. Each is also associated with a range of background knowledge and skills which may not be particular to meteorology and/or hydrology, but are nonetheless essential for the discharge of the weather adviser's duties.

1. Communicate warnings and associated information, including uncertainties and confidence levels, to users

(a) Demonstrates the capability to present information during severe weather events through all relevant media;

(b) Is capable of tailoring weather warning products for communication to disaster management decision-makers and other partners;

(c) Can effectively communicate appropriate levels of confidence and uncertainty to support effective decision-making;

(d) Demonstrates an ability to communicate information to users, including disaster management decision-makers, on the expected impacts of severe weather.

2. Develop products, procedures and services to meet user needs

(a) Demonstrates a knowledge of the meteorological and hydrological information requirements of the disaster management and civil protection community;

(b) Is capable of ensuring that the design and dissemination schedule of warnings meets the decision-making needs of the disaster management community in safeguarding life and property;

(c) Can contribute to the development of very short-range forecasting and nowcasting methods and products tailored for the disaster management community;

(d) Can contribute to the development of DPM user-focused probabilistic forecast products based on Ensemble Prediction System (EPS);

(e) Can contribute to the development of impact-based forecast products designed to assist emergency management agencies with their decision-making processes;

(f) Can contribute to the improved dissemination of warning information through effective utilization of current and emerging communication technologies; and

(g) Is capable of applying new technology and scientific research in Multi-Hazard Early Warning Systems (MHEWS).

3. Develop and manage DPM stakeholder relationships

(a) Demonstrates a capability to establish and maintain working relationships at operational and technical levels with the emergency management community;

(b) Can build and maintain relationships with the media to enable optimal communication of warnings and information prior to, during and after high impact weather events;

(c) Is able to facilitate coordination between the NMHS and relevant agencies to improve emergency planning, preparedness, and response to weather threats, with particular emphasis on the specific needs of megacities where appropriate;

(d) Can assist in the design of effective warning signal systems for coordinated emergency response to meteorological and hydrological hazards;

(e) In close coordination with the emergency management authorities, can contribute to the development of response advice and call-to-action statements based on the potential impact of hazards; and

(f) Is able to manage an appropriate level of expectation in NMHS capacity among DPM stakeholders.

4. Promote and implement impact assessments and community outreach

(a) Can participate in the assessment of the socio-economic impact of meteorological and hydrological events, in collaboration with relevant experts;

(b) Is able to foster coordination with socio-economic experts in order to evaluate the benefits of meteorological and hydrological early warning systems; and

(c) Demonstrates an ability to promote community awareness and preparedness for high impact meteorological and hydrological events through public education and outreach.

5. Ensure the quality of information, services and procedures

(a) Can facilitate sustainable and formalized feedback mechanisms, including user-based service assessment and product verification, for evaluating and improving warnings;

(b) Has the ability to work with disaster management authorities to strengthen the role of NMHSs as the “Single Official Voice” for warnings of high impact weather events;

(c) Can contribute to the development of a communication strategy to ensure credibility of, and effective response to, warnings of high impact weather events;

(d) Can coordinate standard operating procedures relating to multi-agency and multi-hazard risk management and emergency planning;

(e) Is able to contribute to the development of documentation and archiving systems for meteorological and hydrological hazard and impact data, including quality assurance and data management;

(f) Can engage effectively with international projects including the World Weather Information Service (WWIS), the Severe Weather Information Centre (SWIC), METEOALARM, the Severe Weather Forecasting Demonstration Project (SWFDP) and other WMO initiatives as appropriate.

5. COMPETENCY REQUIREMENTS FOR PERSONS ENGAGED IN THE INNOVATION, IMPROVEMENT AND DELIVERY OF METEOROLOGICAL AND HYDROLOGICAL SERVICES AND PRODUCTS

These competency requirements are primarily aimed at NMHSs personnel who are engaged in the area of innovation, improvement, and delivery of meteorological and hydrological services and products. They should be read in conjunction with the competency requirements for a PWS forecaster, although it is recognized that many people engaged in these aspects of NMHSs work may not come from a forecasting background.

(a) Knowledge of meteorology and hydrology, as well as models and systems used in operational forecasting;

(b) Ability to apply existing and new technologies effectively;

(c) Knowledge of user requirements for applications of meteorological and hydrological information.

Each of these competencies is expanded below into second-level competencies that are expressed and structured in a manner that facilitates the clear application of an assessment procedure.

1. Knowledge of meteorology and hydrology, as well as models and systems used in operational forecasting

(a) Demonstrates knowledge of the application of meteorology and hydrology to the improvement of existing services and the creation of new products;

(b) Demonstrates an understanding of the methods used in meteorological and hydrological modelling.

2. Effective application of existing and new technologies

(a) Demonstrates the ability to optimize the systems used to produce and disseminate meteorological and hydrological services and products;

(b) Shows a thorough knowledge of visualization and display systems used for weather information;

(c) Keeps abreast of relevant scientific and technological advances and can specify, lead or contribute to the development of products and services relevant to his/her own NMHS to meet user needs; and

(d) Demonstrates an ability to respond quickly to changing user needs and/or changing technologies.

3. Knowledge of user requirements for applications of meteorological and hydrological information

(a) Maintains an awareness of users' current and future requirements for meteorological and hydrological services;

(b) Demonstrates an ability to create and deliver presentations on topics related to service improvements to users, and to relevant external agencies;

(c) Demonstrates effective communication skills to both internal and external stakeholders and is able to adjust key messages and content for different audiences;

(d) As required, contributes to the development of training material relating to service innovations and improvements.

Recommendation 2 (CBS-Ext.(2014))

AMENDMENTS TO THE *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485)

THE COMMISSION FOR BASIC SYSTEMS,

Noting the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

Noting further:

(1) The *Abridged Final Report with Resolutions of the Sixteenth World Meteorological Congress* (WMO-No. 1077),

(2) The *Abridged Final Report with Resolutions of the Sixty-sixth Session of the WMO Executive Council* (WMO-No. 1136),

(3) The *Final Report of the Extraordinary Meeting of the CBS Implementation Coordination Team of the Open Programme Area Group (OPAG) on Data-processing and Forecasting System (ICT-DPFS)* (Geneva, 21–25 January 2013),

(4) The fundamental changes in the basic systems, including the WMO Integrated Global Observing System and the WMO Information System,

Considering:

(1) The need to include in the *Manual on the Global Data-processing and Forecasting System* the designation of National Meteorological Centre Washington as a Regional Specialized Meteorological Centre for the provision of atmospheric backtracking products,

(2) The need to review in the Manual the regional and global arrangements for (a) the provision of transport model products for environmental emergency response and (b) atmospheric backtracking,

(3) The need to include in the Manual the designation of Regional Climate Centres,

Recommends that the amendments to the *Manual on the Global Data-processing and Forecasting System*, Volume I – Global Aspects, as given in Annexes 1 to 3 to the present recommendation, be adopted, to take effect from 1 July 2015;

Requests the Secretary-General to make the appropriate changes to the Manual, as given in Annexes 1 to 3 to the present recommendation;

Authorizes the president of the Commission, in consultation with the Secretary-General, to make any consequential purely editorial amendments with respect to the Manual.

Annex 1 to Recommendation 2 (CBS-Ext.(2014))

PROPOSED AMENDMENTS TO THE *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485) RELATED TO THE DESIGNATION OF REGIONAL SPECIALIZED METEOROLOGICAL CENTRES FOR THE PROVISION OF ATMOSPHERIC BACKTRACKING PRODUCTS

(Updates to the Manual on GDPFS are in track changes)

The proposed amendment to the *Manual on the GDPFS*, Volume I, relates to the designation of RSMCs for the Provision of Atmospheric Backtracking Products: amendment to Volume I, Part I, Appendix I-1.

VOLUME I, PART I, APPENDIX I-1

[…]

3. The RSMCs with activity specialization are the following:

[…]

Provision of atmospheric transport modelling (for environmental emergency response and/or backtracking)

[…]

RSMC Washington

Annex 2 to Recommendation 2 (CBS-Ext.(2014))

PROPOSED AMENDMENTS TO THE *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485) RELATED TO THE REGIONAL AND GLOBAL ARRANGEMENTS FOR: (A) THE PROVISION OF ATMOSPHERIC TRANSPORT MODEL PRODUCTS FOR ENVIRONMENTAL EMERGENCY RESPONSE; AND (B) ATMOSPHERIC BACKTRACKING

(Updates to the Manual on GDPFS are in track changes)

The proposed amendment to the *Manual on the GDPFS, Volumes I*, relates to the regional and global arrangements for: (a) the provision of transport model products for environmental emergency response; and (b) atmospheric backtracking: amendments to Volume I, Part I, Appendix I-3, and to Volume I, Part II, Appendices II-7 and II-9.

VOLUME I, PART I, APPENDIX I-3

REGIONAL AND GLOBAL ARRANGEMENTS FOR THE PROVISION OF ATMOSPHERIC TRANSPORT MODEL PRODUCTS FOR ENVIRONMENTAL EMERGENCY RESPONSE

SUPPORT FOR NUCLEAR EMERGENCY RESPONSE

NOTIFICATION OF WMO

In the framework of the Convention on Early Notification of a Nuclear Accident, the International Atomic Energy Agency (IAEA) informs the WMO Secretariat and RTH Offenbach (Germany) (DCPC) of the status of the emergency. If needed, the IAEA will request support from the WMO RSMCs. Beginning with a site area emergency, RTH Offenbach (DCPC) will disseminate EMERCON messages on the GTS/WIS in the form of an alphanumeric bulletin in plain-text English language under the abbreviated heading WNXX01 IAEA for global distribution to the NMCs/RSMCs (see also the WMO Manual on the Global Telecommunication System (GTS), WMO-No. 386; and *Manual on the WMO Information System* (WIS), WMO-No. 1060).

When the IAEA no longer requires WMO RSMC support, the IAEA will send an EMERCON termination message to the RSMCs, the WMO Secretariat and RTH Offenbach (DCPC). RTH Offenbach (DCPC) will disseminate the EMERCON termination message on the GTS/WIS in the

form of an alphanumeric bulletin in plain-text English language under the abbreviated heading WNXX01 IAEA for global distribution to the NMCs/RSMCs.

REGIONAL ARRANGEMENTS

The RSMCs designated by WMO for the provision of atmospheric transport model products for nuclear environmental emergency response shall:

1. Provide products only when either the delegated authority[1] of any country in the RSMC region of responsibility or the IAEA requests RSMC support. Upon receipt of a request from the delegated authority[2] or from the IAEA, the RSMC shall provide basic information to the National Meteorological Service[2] of that country or to the IAEA, respectively. If multiple requests are received, highest priority will be given to IAEA requests.

2. Upon receipt of a first request for products related to a nuclear incident and in the absence of a prior notification by the IAEA, inform the WMO Secretariat, all designated RSMCs and the IAEA of the request.

3. For an IAEA request of ~~sent to the RSMCs to~~"all RSMCs generate ~~produce and distribute~~ products and distribute within their region(s)", the lead ~~requested~~ RSMCs will distribute the basic products to the IAEA, and all RSMCs will distribute to all ~~the~~ National Meteorological Services Operational Contact Points in their ~~-~~region(s) of responsibility[3] and the WMO. For a request for support from a Delegated Authority and without a request ~~notification~~ by the IAEA, basic information provided to the National Meteorological Service Operational Contact Point of the requesting country will not be disclosed to the public in that country nor distributed by RSMCs to other National Meteorological Services Operational Contact Points.

4. Provide, on request, support and advice to the IAEA and WMO Secretariats in the preparation of public and media statements. The WMO Secretariat informs relevant NMSs of the public and media statements beforehand, when necessary.

5. Determine the standard set of basic products and the method of delivery in consultation with users and the IAEA.

6. Provide product interpretation guidelines to users.

7. Provide support and technology transfer to national and regional meteorological centres that want to become designated RSMCs.

8. Make arrangements to provide backup services. These would normally be between the two designated centres in a region. Interim arrangements should be made by centres in regions with a single designated RSMC.

9. Provide a joint response, which means that the collaborating RSMCs shall immediately inform one another of any request received; initially all centres with the region should produce and send the basic set of products (charts) independently and then move rapidly towards providing fully coordinated response and services for the duration of the response.

10. Following the initial response, the RSMCs shall develop and provide, and update as required, a "joint statement" to describe a synopsis of the current and forecast meteorological conditions over the area of concern, and the results from the transport models, their differences and similarities and how they apply to the event.

---

[1] The person authorized by the Permanent Representative of the country to request RSMC support.

[2] RSMC products will be provided to the NMS Operational Contact Point designated by the Permanent Representative.

[3] The basic information will be provided by the NMS to the IAEA national contact point and to other agencies as needed based on the specific arrangements defined within the State as discussed in the National Arrangements.

GLOBAL ARRANGEMENTS

Until such time as new RSMCs have been designated, it is proposed that Regional Association VI-designated RSMCs be responsible to provide services for radiological emergencies to Regional Association I; Regional Association IV-designated RSMCs be responsible to provide services to Regional Association III; while the Regional Association V-designated RSMC, in collaboration with Regional Association IV-designated RSMCs, will be responsible to provide services to Regional Association V and the Antarctic.

~~In cases of radiological emergencies where coordination is required between RSMCs of different regions, the RSMCs of the region where the emergency has occurred will provide this coordination.~~

NATIONAL ARRANGEMENTS

The Regional and Global arrangements are designed to respect the authority of a State with regards to information flow within its boundaries. The NMS receiving the RSMC products should determine to which agencies / authorities they should be distributed, based on the arrangements within their State. The Atmospheric Transport Modelling (ATM) products and relevant information provided by the RSMCs are made available to NMS to help them assist nuclear agencies / authorities within their State with the interpretation of the meteorological and ATM products.

VOLUME I, PART II, APPENDIX II-7

USERS' INTERPRETATION GUIDE FOR ATMOSPHERIC TRANSPORT MODEL PRODUCTS PROVIDED BY RSMCs

~~Standards in the provision of international services by RSMCs for nuclear environmental emergency response~~STANDARDS IN THE PROVISION OF INTERNATIONAL SERVICES BY RSMCs FOR NUCLEAR ENVIRONMENTAL EMERGENCY RESPONSE

The Delegated Authority requests support from WMO ~~Regional Specialized Meteorological Centres (~~RSMC~~)~~ for atmospheric transport modelling products by using the form entitled "Environmental Emergency Response — Request for WMO RSMC Support by Delegated Authority". The Delegated Authority then sends the completed form ~~immediately~~ to the RSMCs as per the regional and global arrangements and ensures receipt of the form by phone. This will initiate a joint response from the RSMCs in their region of responsibility.

The ~~International Atomic Energy Agency (~~IAEA~~)~~ requests support from WMO RSMCs for atmospheric transport modelling products by using the form agreed between the WMO and the IAEA. The IAEA then sends the completed form immediately, ~~by fax and~~ by e-mail (preferred) or~~and~~ by fax, to the RSMCs as per the regional and global arrangements and ensures receipt of the form by phone. The lead RSMCs shall confirm receipt of the IAEA request by ~~fax or~~ e-mail (preferred) or fax to IAEA. This will initiate a joint response from the RSMCs in their region of responsibility. The IAEA sends an information copy of its Request Form ~~by fax or~~ by e-mail (preferred) or by fax to RTH Offenbach (DCPC). When the lead RSMCs' products become available, the lead RSMCs shall send an announcement to the IAEA that their respective products are available and the products' location (RSMC's dedicated website), ~~by fax or~~ by e-mail (preferred) or by fax.

The designated RSMCs shall implement agreed standard procedures and products by:

(a) The provision of the following standard set of basic products within two to three hours of reception of a request and according to the general rules for displaying results;

(b) The adoption of standard forecast periods for the numerical calculations;

(c) The adoption of a joint response approach (paragraphs 9 and 10 of the REGIONAL ARRANGEMENTS – Volume I, Part I, Appendix I-3);

(d) The adoption of the general rules for displaying results.

[…]

The RSMCs will distribute their standard products to the NM~~H~~S Operational Contact Points by e-mail and retrieval from RSMCs password protected designated Web site. Standard products in the ITU-T T4 format suitable for both group 3 facsimile machines and transmission on parts of the WIS will be maintained by exception and only if requested by the NM~~H~~S Operational Contact Point. The RSMC may also make use of other appropriate technologies.

[…]

VOLUME I, PART II, APPENDIX II-9

PRODUCTS PROVIDED BY RSMCs WITH ACTIVITY SPECIALIZATION IN ATMOSPHERIC TRANSPORT MODELLING (BACKTRACKING FOR CTBT VERIFICATION SUPPORT)

[...]

The specifications for the backtracking are as follows:

- Simulate a release of 1.3 x 10^{15} Bq of a tracer integrated backward in time (no deposition, no decay) at a constant rate at the point of the station location from surface to 30 m from measurement stop to measurement start.
- Calculate the respective (backward) tracer concentrations [in Bq/m^3] at a global 1 x 1 degree grid, output frequency 3 hours, time average of output 3 hours, from surface to 30 m.
- Simulate backwards in time to the requested ending date/time (up to~~sually~~ 30~~6–14~~ days from issuance of request~~sample collection stop~~).

The PTS shall:

(a) Restrict requests to cases of anomalous radionuclide measurements or system tests;

(b) Contact the RSMCs in case no confirmation of a request was received within 3 hours;

(c) Conduct regular announced and/or unannounced system tests;

(d) Share the results of tests with the other RSMCs at a website;

~~(d)~~(e) Send a cancellation message of the request for support to RSMCs when an issued request is cancelled.

[...]

REQUEST~~NOTIFICATION~~ MAIL MESSAGE FOR SUPPORT SENT OUT BY THE PTS TO WMO RSMCs

REQUEST~~NOTIFICATION~~ MAIL MESSAGE FOR SUPPORT SENT OUT BY THE PTS TO WMO RSMCs

[…]

CANCELLATION MAIL MESSAGE SENT OUT BY THE PTS TO WMO RSMCs

CANCELLATION MAIL MESSAGE SENT OUT BY THE PTS TO WMO RSMCs

====== PTS CANCELS REQUEST FOR SUPPORT =====

Date issued: YYYYMMDD hhmm

FORMAT OF THE MODEL RESULTS AS DELIVERED BY THE RSMCs

FORMAT OF THE MODEL RESULTS AS DELIVERED BY THE RSMCs

Line 1: Header line (station longitude, latitude, start of measurement interval (YYYYMMDD hh), end of measurement interval (YYYYMMDD hh), release strength (Bq), number of hours backward, output every "k" hours, time average of output, horizontal grid space in x direction, horizontal grid space in y direction, station name)

Line 2-k: data lines (latitude, longitude, time step number, value)

17.57 59.23 20030106 09 20030107 09 0.13E+16 144 3 3 1.0 1.0 "SEP63"

58.00 15.00 1 0.1209120E-01

[…]

Annex 3 to Recommendation 2 (CBS-Ext.(2014))

PROPOSED AMENDMENTS TO THE *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485) RELATED TO THE DESIGNATION OF REGIONAL CLIMATE CENTRES

(Updates to the Manual on GDPFS are in track changes)

The proposed amendment to the *Manual on the GDPFS, Volumes I*, relates to the designation of Regional Climate Centres (RCCs): amendment to Volume I, Part I, Appendix I-1.

VOLUME I, PART I, APPENDIX I-1

[…]

Regional Climate Centres providing regional long-range forecasts and other regional climate services:

RCC Africa hosted by ACMAD (RA I)

[…]

RCC WSA hosted by CIIFEN (RA III)

[…]

Recommendation 3 (CBS-Ext.(2014))

INTRODUCTION OF THE NEW *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485)

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The *Abridged Final Report with Resolutions of the Sixteenth World Meteorological Congress* (WMO-No. 1077), Resolution 6 (Cg-XVI) – Revised *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

(2) The *Abridged Final Report with Resolutions and Recommendations of the Fifteenth Session of the Commission for Basic Systems* (WMO-No. 1101), general summary, paragraphs 4.4.13 to 4.4.15,

(3) The *Final Report of the Meeting of the CBS Task Team on the Revision of the Manual on the Global Data-processing and Forecasting System (GDPFS)* (Geneva, 17–19 December 2013),

Considering:

(1) That the *Manual on the Global Data-processing and Forecasting System* is the single source of technical regulations for all operational data-processing and forecasting systems of Members, including their designated meteorological centres,

(2) The fundamental changes in the basic systems, including the WMO Integrated Global Observing System (WIGOS) and the WMO Information System (WIS),

(3) That, similarly to WIGOS and WIS, the Global Data-processing and Forecasting System is an all-encompassing system, including data-processing and forecasting systems coordinated by the Commission, jointly with other technical commissions and/or WMO Programmes, as well as with other international organizations,

Noting further the progress and productive work of experts of the Commission, as well as the collaboration and coordination with other technical commissions and international organizations, in relation to the development of the new revised Manual,

Agrees:

(1) That the GDPFS fosters the orderly evolution of the present WMO data-processing and forecasting systems into an integrated, comprehensive and coordinated system;

(2) That the GDPFS is the basis for the operational production of accurate, reliable and timely weather, climate, water and related environmental forecasts and products by all WMO designated meteorological centres;

(3) That the GDPFS satisfies, in a cost-effective and sustainable manner, the evolving data-processing and forecasting requirements of Members;

Further agrees that the revision of the Manual would facilitate the introduction of updates as frequently as required to ensure that the content is kept up to date;

Recommends:

(1) That the roadmap for the introduction of the new Manual, as given in the annex to the present recommendation, be adopted;

(2) That the Seventeenth World Meteorological Congress grant the authority to the Executive Council to adopt the new revised Manual, as it will be completed after the time of Seventeenth Congress and before the Eighteenth World Meteorological Congress, noting that the revised Manual would not compromise the operation and development of the GDPFS; deferring the adoption of the new Manual until Eighteenth Congress would represent a significant delay in the implementation of important quality management processes and the revised designations of Data-processing and Forecasting Services centres, including a delay of the designation of centres under the new framework until the Nineteenth World Meteorological Congress in 2023;

Invites Members:

(1) To review the draft version of the new Manual and provide their comments to the Secretariat by June 2015, in order to facilitate the review process of the new Manual, prior to its consideration by the World Meteorological Congress or the Executive Council;

(2) To collaborate in, and give all possible support to, the introduction and implementation of the revised Manual, following the roadmap given in the annex to the present recommendation;

Requests the Secretary-General:

(1) To develop an amendment to the *Technical Regulations* (WMO-No. 49) to reflect the evolution of the GDPFS which goes beyond the data-processing and forecasting systems of the World Weather Watch;

(2) To ensure coordination with other components of the World Weather Watch, primarily with WIGOS and WIS, so that the observational and data management aspects related to the GDPFS are included in relevant regulatory documentation;

(3) To arrange for coordination among WMO Programmes and relevant technical commissions to ensure that all WMO relevant operational centres that provide weather, climate, water and environmental products and services are included in the Manual;

(4) To keep and maintain the current version of the Manual in force until the completion of the new revised Manual;

(5) To arrange for the revision of the Manual to be continued so as to achieve its earliest possible completion, subsequent adoption by the World Meteorological Congress or the Executive Council, and publication in all WMO official languages.

Annex to Recommendation 3 (CBS-Ext.(2014))

ROADMAP FOR THE INTRODUCTION OF THE NEW *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485)

Introduction of the new Manual on the GDPFS:

- Draft text (in English) provided to WMO Members around 45 days ahead of CBS-Ext.(2014) (mid July 2014)
- CBS-Ext.(2014) (September 2014) – presentation by OPAG-DPFS co-chairpersons – for information (TECO Focus Session)
- Distribute to ETs and relevant TCs for comments and any proposed contributions and updates, including WIGOS/WIS to review relevant parts (mid-July 2014)
- Consolidate all inputs by end January 2015
    - Post on web for comments (end January 2015) – announce to ET chairpersons
- Distribute consolidated text (in English) to WMO Members (end January 2015) – deadline for comments by WMO Members: May 2015
- Collection of feedback from WMO Members by end June 2015
- Letter to all existing Centres to request them to confirm the mapping of their activities onto the new designations (by July 2015) – deadline October 2015

- Final editing by December 2015
- Translation to 4 languages for CBS-16 (2016)
- Approval of the draft text of the new Manual by EC (June 2017)
- Letter to PRs and RAs inviting nominations for new DPFS centres (July 2017)
- Assessment of compliance of centres with new Manual by CBS session before Cg-18 (2019)]

Transitional arrangements:

- Transition Period: EC-67 (June 2015) to Cg-18 (2019)
- Existing WMCs and RSMCs will retain their status until Cg-18 (2019)
  - To retain status after Cg-18, they need to demonstrate compliance by Cg-18
- Regular compliance assessment as described in the revised Manual starts after EC-67 (June 2015)
- New centres will be recognized as formal WMCs or RSMCs as soon as they reach the compliance which is reviewed by CBS and receive the approval from Cg or EC.

Recommendation 4 (CBS-Ext.(2014))

AMENDMENTS TO *THE MANUAL ON THE GLOBAL TELECOMMUNICATION SYSTEM* (WMO-No. 386)

THE COMMISSION FOR BASIC SYSTEMS,

Noting that the Global Telecommunication System (GTS) remains a key component of the WMO Information System (WIS),

Noting further:

(1) Resolution 1 (Cg-XVI) – World Weather Watch Programme for 2012–2015,

(2) Resolution 45 (Cg-XVI) – Technical Regulations of the World Meteorological Organization,

(3) That the *Manual on the Global Telecommunication System* (WMO-No. 386), Volume II – Regional Aspects is not regulatory but that:

(a) Information contained within it is important for efficient and effective operation of the GTS,

(b) Changes in technology are reducing the need for regional practices,

(c) The need to be able to ensure the operational integrity and performance of telecommunication systems and data flow in WIS, including the GTS, is dependent on access to up-to-date information on contributing systems,

(4) That data designators are used to provide a brief description of the contents of messages exchanged on the GTS,

(5) That Volume I – Global Aspects of the Manual refers to the *Technical Regulations* (WMO-No. 49), Volume I – General Meteorological Standards and Recommended Practices that has been updated since some of the cross references were written,

(6) That additional explanation of the WMO general file naming convention would be helpful,

Recommends:

(1) That Volume I of the Manual be updated editorially to align with Volume I of the *Technical Regulations*, as indicated in the annex to the present recommendation;

(2) That Volume II of the Manual be discontinued and replaced by web-based documentation that should be reviewed and updated as required;

(3) That Members include national and regional information in messages distributed globally to meet the needs of global numerical weather prediction;

Requests the Secretary-General to make the amendments to Volume I of the Manual, as given in the annex to the present recommendation, and to publish on the WMO website relevant information from Volume II of the Manual;

Authorizes the Secretary-General to make any consequent purely editorial changes to Volume I of the Manual or to the WMO website that are consequential on the present recommendation.

Annex to Recommendation 4 (CBS-Ext.(2014))

CONSISTENCY WITH THE *TECHNICAL REGULATIONS* (WMO-No. 49)

Change Part I paragraph 1.4.2

In addition to the responsibilities stated explicitly in the Technical Regulations (WMO-No. 49), Volume I, Part I, ~~3.3.4~~3.4.1, the following principles …

Data designators

Change columns T2, A1, and A2 a line in Table A of Attachment II-5:

T1	*Data Type*	*T2*	*A1*	*A2*	*ii*	*Priority*
L	Aviation information in XML	B7	C1	C1	(1)	1/2/3

Modify the note to Table B7 of Attachment II-5 as follows:

Note: Data that are expressed in extensible markup language (XML) and use data designators of ~~with~~ T1=L and T2=A, C, P, S, T, V, and Y are ~~AvXML – aviation XML. Aviation XML es expected to be assigned a FM number in the future.~~ using IWXXM (FM-205).

Add a line in Table B1 of Attachment II-5 in the sub-table for T1 = S

T_2 Designator	*Data Type*	*Code form (name)*
H	Reports from DCP stations	(any format)

Add a line in Table B1 of Attachment II-5 in the sub-table for T1 = W

T_2 Designator	*Data Type*	*Code form (name)*
R	Humanitarian activities	(any format)

Add new entries in Table C6 of Attachment II-5:

T_1T_2	*A1*	*ii*	*Data type*	*TAC correspondence*	*Data category subcategory (Common Table C13)*
IN	C		CrIS (selected channels)		003/030
IN	I		IRAS		003/020
IN	J		HIRAS		003/030
IN	K		MWHS/MWHS-2		003/040
IN	Q		IASI (Principle component scores)		003/007
IN	S		ATMS		003/040
IN	T		MWTS/MWTS-2		003/040

Clarification of intention

In Attachment II-15, in the definition of the <location indicator> element of the product identifier component of the general file naming convention , add the following note after the first bullet point.

Note: although ISO 3166 uses only upper case letters, WMO file names may use either upper or lower case letters for the ISO 2-letter country code and both cases are considered identical when comparing file names.

Recommendation 5 (CBS-Ext.(2014))

AUTHORIZING USE OF THE PROCEDURE FOR AMENDING MANUALS BETWEEN SESSIONS OF THE COMMISSION FOR BASIC SYSTEMS IN RESPONSE TO AMENDMENTS TO ANNEX 3 TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

THE COMMISSION FOR BASIC SYSTEMS,

Noting that responsibility for updating the regulations for exchanging meteorological information of relevance to international civil aviation is shared between the World Meteorological Organization (WMO) and the International Civil Aviation Organization (ICAO),

Noting further:

(1) That the pertinent technical regulations of ICAO are documented in Annex 3 to the Convention on International Civil Aviation – *Meteorological Service for International Air Navigation*, and that the *Technical Regulations* (WMO-No. 49), Volume II, Parts I and II, have the same content as ICAO Annex 3,

(2) That the Executive Council at its sixty-first session approved the procedure for adoption of amendments to the *Manual on Codes* (WMO-No. 306), Volume I.2 between sessions of the Commission,

(3) That the Executive Council at its sixty-first session requested the Commission to limit amendments for adoption between CBS sessions to those that had no operational impact or financial burden on Members (*Abridged Final Report with Resolutions of the Sixty-first Session of the Executive Council* (WMO-No. 1042), general summary, paragraph 3.5.2.8),

(4) That the schedules for decision-making sessions of the ICAO Council and that of the Commission are not synchronized, such that decisions by the ICAO Council may need to be implemented before the next session of the Commission,

(5) That amendments adopted by the ICAO Council will have operational impacts for those Members of WMO that are also Contracting States of ICAO, and that the amendments may consequently place a financial burden on such Members,

(6) That Members that are also Contracting States of ICAO will have been consulted by ICAO in the preparation of amendments to ICAO Annex 3,

Recommends that the Commission be authorized to apply the procedure for adoption of amendments between its sessions to changes to the *Manual on Codes*, Volume I.2 and Volume I.3, the *Manual on the Global Telecommunication System* (WMO-No. 386) and the *Manual on the WMO Information System* (WMO-No. 1060) that are required to support the implementation of amendments to ICAO Annex 3;

Requests the Secretary-General to arrange for editorial changes to be made to these Manuals to record this recommendation.

Recommendation 6 (CBS-Ext.(2014))

AMENDMENTS TO THE *MANUAL ON CODES* (WMO-No. 306), VOLUME I.2 – AMENDMENTS TO REGULATIONS FOR REPORTING TRADITIONAL OBSERVATION DATA IN TABLE DRIVEN CODE FORMS: BUFR OR CREX

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 1 (Cg-XVI) – World Weather Watch Programme for 2012–2015,

(2) Resolution 45 (Cg-XVI) – Technical Regulations of the World Meteorological Organization,

(3) The *Manual on Codes* (WMO-No. 306), Volume I.2,

Considering the requirements of standard reporting practices of Table Driven Code Forms (TDCF) for height and amount of clouds in surface observations and date and time in CLIMAT reporting in accordance with regional practices,

Recommends that tables of FM 94 BUFR and the Regulations for reporting traditional observation data in Table Driven Code Forms (TDCF): BUFR or CREX be amended, as given in the annex to the present recommendation, with effect from 4 November 2015;

Requests the Secretary-General to arrange for the inclusion of these amendments to Volume I.2 of the Manual;

Further requests the Secretary-General to notify Members of the amendments so that they can incorporate them in relevant software when it is not possible to meet the urgent requirements;

Authorizes the Secretary-General to make any consequent purely editorial amendments to the Manual.

Annex to Recommendation 6 (CBS-Ext.(2014))

AMENDMENTS TO THE *MANUAL ON CODES* (WMO-No. 306), VOLUME I.2

Part B – Binary Codes:

FM 94 BUFR

Amend *LST* to *LT* in the *Element description* column of 3 07 071, 3 07 072, 3 08 011 and 3 08 012 in BUFR Table D.

Part C – Common Features to Binary and Alphanumeric Codes,

Regulations for reporting traditional observation data in Table Driven Code Forms (TDCF): BUFR or CREX

Amend *LST* to *LT* in TM307073 and TM308013.

Amend the Notes (1) and (2) to TM307073 (B/C30) and TM308013 (B/C32),

(1) The time identification refers to the beginning of the one-month period. Except for precipitation measurements, the one-month period is recommended to correspond to the local ~~standard~~ time (~~LST~~LT) month. ~~[7]~~

(2) In case of precipitation measurements, the one-month period begins at 06 UTC on the first day of the month and ends at 06 UTC on the first day of the following month. ~~[5]~~

Add new regulations:

B/C 1.4.4.4.4, B/C 5.4.4.4.4 and B/C 10.4.4.4.3

If synoptic data are produced in BUFR or CREX by conversion from a TAC report, the following approach shall be used: Height of base of the lowest cloud 0 20 013 shall be derived from the h_sh_s in the first group 8 in section 3, i.e. from the h_sh_s of the lowest cloud. If and only if groups 8 are not reported in section 3, 0 20 013 may be derived from h. The lower limit of the range defined for h_sh_s and for h shall be used. However, if groups 8 are not reported in section 3 and h = 9 and $N_h \neq 0$, then 0 20 013 shall be 4000 m; if groups 8 are not reported in section 3 and h = 9 and $N_h = 0$, then 0 20 013 shall be 8000 m.

Add (d), (e) and (f) in the following regulations:

B/C 1.4.4.3.1, B/C 5.4.4.3.1 and B/C 10.4.4.3.1

(d) If no clouds are observed (clear sky), then the cloud amount shall be reported as 0.

(e) If sky is obscured by fog and/or other meteorological phenomena, then the cloud amount shall be reported as 9.

(f) If cloud cover is indiscernible for reasons other than fog or other meteorological phenomena, or observation is not made, the cloud amount shall be reported as missing.

Amend B/C 30.4:

B/C 30.4 Regional or national reporting practices

B/C 30.4.1 Data required by regional or national reporting practices

No additional data are currently required by regional or national reporting practices for CLIMAT data in *Manual on Codes*, WMO-No. 306, Volume II.

B/C 30.4.2 Reference period for the data of the month

If the regional or national reporting practices require reporting monthly data (with the exception of precipitation data) for one-month period different from the local time month as recommended in B/C 30.2.2.1, short time displacement (0 04 074) shall be adjusted accordingly.

B/C 30.4.3 Date/time (of beginning of the period for monthly precipitation data)

If the regional or national reporting practices require reporting monthly precipitation data for period different from the period recommended in Note (1) to B/C 30.2.6.1, then hour (0 04 004) shall be adjusted accordingly. This regulation does not apply if the beginning of the period for monthly precipitation data starts on the last day of the previous month in UTC.

Amend B/C 32.4:

B/C 32.4 Regional or national reporting practices

B/C 32.4.1 Data required by regional or national reporting practices

No additional data are currently required by regional or national reporting practices for CLIMAT SHIP data in *Manual on Codes*, WMO-No. 306, Volume II.

B/C 32.4.2 Reference period for the data of the month

If the regional or national reporting practices require reporting monthly data (with the exception of precipitation data) for one-month period different from the local time month as recommended in B/C 32.2.2.1, short time displacement (0 04 074) shall be adjusted accordingly.

B/C 32.4.3 Date/time (of beginning of the one-month period for precipitation data)

If the regional or national reporting practices require reporting monthly precipitation data for one-month period different from the period recommended in Note (1) to B/C 32.2.3.1, then hour (0 04 004) shall be adjusted accordingly. This regulation does not apply if the beginning of the period for monthly precipitation data starts on the last day of the previous month in UTC.

Amend B/C 30.2.2.1 and B/C 32.2.2.1:

Monthly data (with the exception of precipitation data) are recommended to be reported for one-month period, corresponding to the local ~~standard~~ time (~~LST~~LT) month [*Handbook on CLIMAT and CLIMAT TEMP Reporting* (WMO/TD-No.1188)]. In that case, short time displacement (0 04 074) shall specify the difference between UTC and ~~LST~~LT (set to *non-positive values in the eastern hemisphere, non-negative values in the western hemisphere*).

Time period (0 04 023) represents the number of days in the month for which the data are reported, and shall be expressed as a *positive value* in days.

Amend Note (1) to B/C 30.2.6.1 and B/C 32.2.3.1:

(1) In case of precipitation measurements, a month begins at 0600 hours UTC on the first day of the month and ends at 0600 hours UTC on the first day of the following month [*Handbook on CLIMAT and CLIMAT TEMP Reporting* (WMO/TD-No.1188)].

Amend B/C 30.3.1.2 and B/C 32.3.1.2:

The one-month period for which the normal values are reported shall be specified by month (0 04 002), day (0 04 003) being set to 1, hour (0 04 004) being set to 0, short time displacement (0 04 074) being set to (UTC – LT) and time period (0 04 022) being set to 1, i.e. 1 month. Short time displacement (0 04 074) shall be set to non-positive values in the eastern hemisphere, non-negative values in the western hemisphere.

Amend second paragraph of B/C 30.2.5.3:

Lowest daily mean temperature (~~0 12 152~~0 12 153) shall be reported in degrees Kelvin (with precision in hundredths of a degree Kelvin); if produced in CREX, in degrees Celsius (with precision in hundredths of a degree Celsius).

Recommendation 7 (CBS-Ext.(2014))

AMENDMENTS TO THE *MANUAL ON CODES* (WMO-No. 306), VOLUME I.2 – REPRESENTATION OF MISSING CHARACTER STRINGS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 1 (Cg-XVI) – World Weather Watch Programme for 2012–2015,

(2) Resolution 45 (Cg-XVI) – Technical Regulations of the World Meteorological Organization,

(3) The *Manual on Codes* (WMO-No. 306), Volume I.2,

Considering

(1) The requirements of standard reporting practices of Table Driven Code Forms for missing character strings in BUFR messages,

(2) That one of the GRIB templates is no longer appropriate for use because it does not allow sufficient octets to represent forecast time,

Recommends that the regulations of FM 94 BUFR and the templates of FM 92 GRIB be amended, as given in the annex to the present recommendation, with effect from 4 November 2015;

Requests the Secretary-General to arrange for the inclusion of these amendments to the *Manual on Codes*, Volume I.2;

Authorizes the Secretary-General to make any consequent purely editorial amendments to Volume I.2 of the Manual.

Annex to Recommendation 7 (CBS-Ext.(2014))

AMENDMENTS TO THE *MANUAL ON CODES* (WMO-No. 306), VOLUME I.2 – REPRESENTATION OF MISSING CHARACTER STRINGS

Part B – Binary Codes:

FM 94 BUFR

Amend Regulations:

94.1.5 Missing values shall be expressed by all bits set to 1 within the data width of the element ~~(e.g. each octet shall be set to 11111111 binary)~~. This shall apply to ~~code tables as well as data elements; flag tables shall be augmented to contain a missing indicator bit where this is deemed to be necessary~~ all Table B elements, including elements defined as CCITT IA5, code tables and flag tables, with the exception of data description operator qualifiers in Class 31.

Note: Flag tables are always augmented to contain an additional bit as the least significant bit of the table. All bits, including this additional bit, shall be set to 1 to express a missing value, but in all other cases this additional bit shall be set to 0. This note does not apply to Data present indicator 0 31 031.

94.1.6 The convention for representing missing data for compressed data within the binary Data section shall be to set the corresponding increments to fields ~~of all ones~~ so that all bits are set to 1.

94.1.7 When a local reference value for a set of element values for compressed data is represented as all ~~ones~~bits set to 1, this shall imply that all values in the set are missing.

Amend (iii) and (vi) in Note (2) to Regulation 94.6.3:

(iii) If all values of an element are missing, R^0 shall be coded with all bits set to 1~~s~~;

(vi) Missing values will be denoted by setting all bits of the corresponding I to 1~~s~~;

FM 92 GRIB

Add a new note to GRIB Product definition template 4.44 – analysis or forecast at a horizontal level or in a horizontal layer at a point in time for aerosol

Note: It is recommended not to use this template. PDT 4.48 should be used instead with optical wave length range set to missing.

Recommendation 8 (CBS-Ext.(2014))

MIGRATION TO TABLE DRIVEN CODE FORMS

THE COMMISSION FOR BASIC SYSTEMS,

Noting that it is not possible to represent some information in Traditional Alphanumeric Codes,

Noting further:

(1) The intention of the Commission at its extraordinary session in 2010 that migration to Table Driven Code Forms should be completed by November 2014,

(2) The request of the Commission at its extraordinary session in 2010 for Regional Telecommunication Hubs to convert between Traditional Alphanumeric Forms and Table Driven Code Forms on behalf of Members,

Recommends that Members adding new reports for exchange using the Global Telecommunication System should not use Traditional Alphanumeric Code to represent the information.

Recommendation 9 (CBS-Ext.(2014))

ESTABLISHMENT OF A SATCOM USERS' FORUM

THE COMMISSION FOR BASIC SYSTEMS,

Noting the important role of satellite Data Collection Systems in making available data and observations from remote and mobile observation platforms operating within programmes of both WMO and the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization,

Noting further:

(1) That the Commission has been working with the Joint WMO/IOC Commission for Oceanography and Marine Meteorology, bringing together experts from the satellite Data Collection Systems user and supplier community (ad hoc SATCOM meetings), to investigate the establishment of an international mechanism, covering the wide user base that exists within the co-sponsoring organizations, to address remote data communication requirements including tariff negotiations as needed, for automatic environment observing systems using satellite data telecommunication systems,

(2) The recommendations of the ad hoc meetings on how a SATCOM Forum may choose to operate, in particular:

(a) Membership from co-sponsoring organizations and user forums,

(b) Observers, including representatives from SATCOM system operators, service providers and equipment manufacturers,

(c) Governance, office bearers, secretariat support and frequency of meetings,

Recommends:

(1) That the Seventeenth World Meteorological Congress approve a WMO-IOC International Forum of Users of Satellite Data Telecommunication Systems (SATCOM) with terms of reference, as given in the annex to the present recommendation;

(2) That the Commission for Basic Systems, as the lead technical commission, in collaboration with the Joint WMO/IOC Commission for Oceanography and Marine Meteorology, proceed to establish the SATCOM Forum, taking into consideration the recommendations of the initial SATCOM meetings;

Requests the Secretary-General to continue to support this development activity, including consideration of budget implications associated with the organizational and operating practices to establish and maintain the forum.

Annex to Recommendation 9 (CBS-Ext.(2014))

TERMS OF REFERENCE FOR A WMO-IOC INTERNATIONAL FORUM OF USERS OF SATELLITE DATA TELECOMMUNICATION SYSTEMS

The International Forum of Users of Satellite Data Telecommunication Systems (SATCOM) is an entirely self-funded body jointly sponsored by the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, of the United Nations in the view to address the requirements of these two organizations for the timely collection via satellite of environmental data from observing platforms.

The forum shall:

(a) Provide coordination amongst the users of satellite data telecommunication systems (SDTS) and represent their collective interests in working with the satellite telecommunication service providers and the industry in order to advance the awareness and understanding of the user requirements;

(b) Advance the awareness and understanding of available and planned capabilities;

(c) Facilitate adoption of interoperability and quality standards and principles as needed;

(d) Investigate and propose as needed cooperative tariff negotiation mechanisms on the use of satellite data telecommunication systems;

(e) Facilitate the preparation of technical advice and guidance that will optimize STDS choices for each considered application;

(f) Report to the executive bodies of WMO and IOC through the Commission for Basic Systems (CBS), the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM), and the Global Ocean Observing System (GOOS) Steering Committee respectively.

Membership is open to all representatives of the co-sponsors stakeholders, that is:

Representatives of the co-sponsoring Organizations Members/Member States,

Representative of a User Group,

SATCOM system providers,

Representatives of the satellite equipment manufacturers.

Recommendation 10 (CBS-Ext.(2014))

REPRESENTATION OF AVIATION INFORMATION IN EXTENSIBLE MARKUP LANGUAGE

THE COMMISSION FOR BASIC SYSTEMS,

Noting that the International Civil Aviation Organization decided to permit the exchange of operational information in extensible markup language (XML) in support of international civil aviation,

Noting further:

(1) That, under the working arrangements with the International Civil Aviation Organization, WMO is responsible for defining and documenting the data formats used to exchange meteorological information in support of international civil aviation,

(2) That the Commission had developed representations in XML for the information exchanged in TAF, METAR, SPECI and SIGMET messages,

(3) That the nature of XML representations of information differs significantly from those in the Traditional Alphanumeric Codes or Table Driven Code Forms,

(4) That the XML representations are based on a logical data-modelling approach,

(5) That XML representations of information are most useful when the definitions of code list entries referred to within the XML document are available as an online resource,

(6) That details of how the XML representations were derived and of the logical data model that underpin them will be required for reference by those extending the logical data model to representations of other WMO information,

Recommends:

(1) That the Seventeenth World Meteorological Congress introduce a third volume, Volume I.3, of the *Manual on Codes* (WMO-No 306) to document data representations that are derived from a logical data-modelling approach;

(2) That the XML representations of meteorological information supporting international civil aviation, as documented in Annex 1 to the present recommendation, be adopted with effect from 1 January 2016;

(3) That Seventeenth Congress request the Secretary-General to publish reference copies of the XML schemas, code lists and other machine-readable entities that are required for operational use of XML data representations on the Internet using the wmo.int domain;

(4) That Seventeenth Congress authorize the Secretary-General to make any consequent purely editorial amendments to Volumes I.1, I.2 or I.3 of the Manual;

Requests the Secretary-General:

(1) To publish Volume I.3 of the Manual, as contained in Annex 1 to the present recommendation, in English, French, Russian and Spanish;

(2) To publish in English only the Guidelines on data modelling for WMO codes, as contained in Annex 2 to the present recommendation, as a reference document for those developing data representations based on data models;

Authorizes the Secretary-General to make any purely editorial amendments to the text of the documentation in Annex 1 or Annex 2 prior to submission to Seventeenth Congress.

Annex 1 to Recommendation 10 (CBS-Ext.(2014))

***MANUAL ON CODES* (WMO-NO. 306), VOLUME I.3**

Manual on Codes

International Codes

Volume I.3

(Annex II to WMO Technical Regulations)

Part D – Representations derived from data models

WMO-No. 306

2015 edition

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PUBLICATION REVISION TRACK RECORD

Date	*Part/chapter/section*	*Purpose of amendment*	*Proposed by*	*Approval resolution of Cg or EC*
July 2015	Part D	Introduce IWXXM. Create Vol I.3.	EC-67	Resolution ?? Cg-17

EDITORIAL NOTE

Typefaces employed in this volume do not signify standard or recommended practices, and are used solely for legibility.

For the purposes of drafting only:

Text copied from Volume I.1 or Volume I.2 of the Manual on Codes is denoted thus, using Word style "_Moved_destination"

Text deleted from Volume I.1 or Volume I.2 of the Manual on Codes is denoted ~~thus, using Word style "_Deleted text".~~

Text added to from Volume I.1 or Volume I.2 of the Manual on Codes is denoted thus, using Word style "_Added text".

New text that is not contained within a section of text copied from Volume I.1 or Volume I.2 of the Manual on Codes is in the font and style intended for publication.

Preface

[Instruction to editors: Copy the Preface from the existing volumes of the Manual on Codes. The Third paragraph of the Preface should be modified in the existing Vol I.1 and Vol I.2 as well as in the new Volume I.3 to match the changes below.]

Rules concerning the selection of code forms to be exchanged for international purposes, and the selection of their symbolic words, figure groups and letters, are laid down in the WMO Technical Regulations, Volume I, Chapter A.2.3 (1988 edition). These code forms are contained in Volume I of the Manual on Codes, issued as Volume I.1 – Part A, and Volume I.2 – Part B and Part C and Volume I.3 – Part D.

[Instruction to Editors: The final paragraph of the Preface (that is specific to the Volume) in Vol I.3 is]

This is the first Edition of Volume I.3 of the Manual on Codes and introduces the use of Extensible Markup Language (XML).

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INTRODUCTION

[Instruction to Editors: copy the Introduction from the existing volumes I.1 and I.2 into Volume I.3. The changes marked must be made in all three volumes.]

Volume I of the Manual on Codes contains WMO international codes for meteorological data and other geophysical data relating to meteorology; it constitutes Annex II of the WMO Technical Regulations and has therefore the status of a Technical Regulation. It is issued in two three volumes: Volume I.1, containing PART A, and Volume I.2, containing PART B and PART C, Volume I.3 containing PART D.

VOLUME I.1:

Part A – Alphanumeric Codes consists of five sections. The standard coding procedures are distinguished by the use of the term “shall” in the English text, and by suitable equivalent terms in the French, Russian and Spanish texts. Where national practices do not conform with these regulations, Members concerned shall formally notify the Secretary-General of WMO for the benefit of other Members.

VOLUME I.2:

Part B – Binary Codes consists of the list of binary codes with their specifications and associated code tables. Explanatory notes are sometimes added to regulations.

Part C – Common Features to Binary and Alphanumeric Codes consists of the list of table-driven alphanumeric codes with their specifications and associated code tables, and of common code tables to binary and alphanumeric codes and other WMO data representations.

The attachments (yellow background) to Volume I.2 do not have the status of WMO Technical Regulations and are given for information only.

Volume I.3:

Part D – Representations derived from data models consists of the specification of the list of standard representations derived from data models, including those using Extensible Markup Language (XML), with their specifications and associated code tables.

[Note to Editors: the following paragraph is only needed if the draft text contains non-regulatory attachments]

The attachments (yellow background) to Volume I.3 do not have the status of WMO Technical Regulations and are given for information only.

[Instruction to editors: copy the definitions section from Volume I.1 into Volume I.3 Add the following into the definitions section at the appropriate place in all three Volumes].

DEFINITIONS

All-components schema document

An XML schema document that includes, either directly, or indirectly, all the components defined and declared in a namespace.

Application Schema

An *Application Schema* is a conceptual schema for data required by one or more applications. (Source: ISO 19101:2002, definition 4.2)

Extensible Markup Language (XML)

Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. It is defined in the W3C XML 1.0 Specification.

GML application schema

A *GML application schema* is an application schema written in XML Schema in accordance with the rules specified in ISO 19136:2007.

GML document

An XML document with a root element that is one of the XML elements Abstract Feature, Dictionary or TopoComplex specified in the GML schema or any element of a substitution group of any of these XML elements.

GML schema

The XML schema components in the XML namespace http://www.opengis.net/gml/3.2 as specified in ISO 19136:2007.

Namespace

A *namespace* is a collection of names, identified by a URI reference, which are used in XML documents as element names and attribute names.

Root element

Each XML document has exactly one *root element.* This element, also known as the document element, encloses all the other elements and is therefore the sole parent element to all the other elements. The root element provides the starting point for processing the document.

Schematron

Schematron is a definition language for making assertions about patterns found in XML documents, differing in basic concept from other schema languages in that it not based on grammars but on finding patterns in the parsed document.

Uniform Resource Identifier (URI)

A *Uniform Resource Identifier (URI)* is a compact sequence of characters that identifies an abstract or physical resource. URI syntax is defined in IETF RFC3986.

XML Attribute

A start tag delimiting a XML Element may contain one or more *attributes*. Attributes are Name-Value pairs, with the Name in each pair referred to as the attribute name and the Value (the text between the ' or " delimiters) as the attribute value. The order of attribute specifications in a start-tag or empty-element tag is not significant.

XML document

A structured document conforming to the rules specified in Extensible Markup Language (XML) 1.0 (Second Edition).

XML element

Each XML document contains one or more *elements*, the boundaries of which are either delimited by start-tags and end-tags, or, for empty elements, by an empty-element tag. Each element has a type, identified by name, sometimes called its "generic identifier" (GI), and may have a set of attribute specifications. An XML element may contain other XML elements, XML attributes or character data.

XML schema

XML Schema is a definition language offering facilities for describing the structure and constraining the contents of XML documents. The set of definitions for describing a particular XML document structure and associated constraints is referred to an XML Schema Document (XSD).

XML schema document

An XML document containing XML schema component definitions and declarations.

A. FM SYSTEM OF NUMBERING XML MARKUP LANGUAGE APPLICATION SCHEMAS

Each extensible markup language (XML) application schema bears a number, preceded by the letters FM. This number is followed by a numeral to identify the session of the Commission for Basic Systems that either approved the XML application schema as a new one or made the latest amendment to its previous version. An extensible markup language application schema approved or amended by correspondence after a session of the Commission for Basic Systems receives the number of that session.

Furthermore, an indicator term is used to designate the XML representation colloquially and is therefore called a "code name".

Notes on nomenclature:

(a) Changes and augmentations to the structure of the XML data representation shall be identified as different “editions”. Each edition of the XML code is allocated a unique namespace. To distinguish between editions, namespaces include EITHER a year field, denoting the year in which those changes and augmentations were begun, OR a version number. For example, FM 202-15 Ext. METCE-XML has namespace http://def.wmo.int/metce/2013 (initial year of work 2013) whilst FM 205-15 Ext. IWXXM-XML has namespace http://icao.int/iwxxm/1.1 (version number 1.1).

(b) Changes to the content of any of the supporting tables are backward compatible. Terms used within the supporting tables may be deprecated; they will not be deleted. Once changes to the supporting tables are approved, a snapshot containing all the supporting tables required for XML codes will be published. Each snapshot is referred to as a “table version”. The current table version for XML codes is Version 1.

(c) Backward compatible changes, including addition of new elements or attributes to supporting tables, do not require a new edition of the XML code.

(d) Further XML code editions and table versions may be generated independently of one another in the future as requirements dictate.

The following table lists XML application schemas included within the FM numbering system, together with the corresponding code names and their reference list of Congress, Executive Council or CBS approval decisions.

FM SYSTEM OF EXTENSIBLE MARK UP LANGUAGE REPRESENTATIONS

FM 201-15 Ext. COLLECT-XML	Collection of reports that use the same XML application schemas. Res. X (Cg-17)
FM 202-15 Ext. METCE-XML	Meteorological Information. “Modéle pour l’Échange des informations sur le Temps, le Climat et l’Eau.” A set of foundation building blocks to support application schema in the domains of interest to WMO, notably the weather, climate, hydrology, oceanography and space weather disciplines. Res. X (Cg-17)

FM 203-15 Ext. OPM-XML	Observable Property Model. Based on work by the Open Geospatial Consortium Sensor Web Enablement Working Group, this allows observable properties (also known as “quantity kinds”) to be aggregated into groups, and for any qualification or constraint relating to those observable properties to be described explicitly. Res. X (Cg-17)
FM 204-15 Ext. SAF-XML	Simple Aeronautical Features. Allows items such as airports, or runways to be described to the level of detail required for reporting weather information for international civil aviation purposes. Res. X (Cg-17)
FM 205-15 Ext. IWXXM-XML	International Civil Aviation Organization Meteorological Information Exchange Model - defines the reports required by ICAO (with information content equivalent to that in the alphanumeric METAR/SPECI, TAF and SIGMET code forms) that are built from the components of the packages managed by WMO. Res. X (Cg-17)

1 REPRESENTATION OF INFORMATION IN EXTENSIBLE MARKUP LANGUAGE

1.1 Extensible markup language (XML) documents shall be well-formed with respect to XML 1.0 [Extensible Markup Language (XML) 1.0 (Second Edition)].

Note: the XML implementation specified in this Manual (WMO-No.306 the Manual on Codes) is described using the XML Schema language (XSD) [XML Schema Part 1: Structures (Second Edition), XML Schema Part 2: Datatypes (Second Edition)] and Schematron [ISO/IEC 19757-3:2006, Information technology – Document Schema Definition Languages (DSDL) – Part 3: Rule-based validation – Schematron].

Note: within this Manual, XPath [XML Path Language (XPath) 2.0 (Second Edition)] is used to refer to particular elements and attributes within an XML document.

1.2 XML documents conforming to XML schema that have been allocated an FM identifier within this Manual shall, in addition to conforming to the Regulation for the specified code form, conform to the requirements specified in Clauses 7 to 19 of ISO 19136:2007 [ISO 19136:2007, Geographic information – Geography markup language (GML)].

Note: XML Schema defined in this Manual are conformant to the encoding rules specified in ISO 19136:2007 and are categorized as “GML application schema”. Similarly, XML documents conforming to requirements from ISO 19136:2007 are termed “GML documents”.

Note: Conformance tests for GML documents are provided in Annex A.3 of ISO 19136:2007 - Abstract test suite for GML documents.

Note: the Content-Type [IETF RFC 2387 MIME Multipart/Related Content Type] for GML documents is “application/gml+xml”.

1.3 Information exchanged in XML using the WMO Information System (WIS) shall conform to publicly available GML application schemas.

1.4 Information that is exchanged as XML using the WIS and that capable of being represented according to the GML application schema defined in this Manual should conform to the GML application schema defined within this Manual.

1.5 Creators of GML documents conforming to GML application schema defined in this Manual shall ensure that their GML documents are valid with respect to the associated XML schema documents (XSD).

1.6 Creators of GML documents conforming to GML application schema defined in this Manual shall ensure that their GML documents validate against the associated Schematron schema(s) that test conformance with the specified GML application schema.

Note: it is not necessary for recipients to validate each document.

1.7 All date-time elements shall be encoded using ISO 8601 extended time format [ISO 8601:2004, Data elements and interchange formats – Information interchange – Representation of dates and times].

1.8 The value of each time element shall include a time zone definition according to the ISO 8601 standard. The time zone provided should be UTC.

Note: a time zone is specified using a signed 4 digit character or a ‘Z’ to represent Zulu or Coordinated Universal Time (UTC) according to the following regular expression: (Z|[+-]HH:MM)

1.9 All units of measure shall use the appropriate code from the Unified Code for Units of Measure (UCUM) code system. The unit of measure shall be identified by encoding the UCUM code in the “uom” attribute of the gml:MeasureType. Where no UCUM code is provided for the unit of measure, the unit of measure should be identified using a URI that resolves to an online definition that is recognised by some level of authority,

Note: the UCUM base codes are available in XML form at: http://unitsofmeasure.org/ucum-essence.xml

Note: a list of unit of measures appropriate to the weather, water and climate domains are provided at http://codes.wmo.int/common/c-6. Each unit of measurement listed therein has a URI identifier.

1.10 Where an xlink:href attribute is used to reference a resource from within an XML document, the xlink:title attribute should not be used to provide a textual description of that resource.

2 UNIQUE IDENTIFIERS TO IDENTIFY CODE TABLE ITEMS AND DEFINITIONS

2.1 The GML application schemas defined in this Manual make extensive use of externally managed codes and vocabulary items, with majority drawn from Code Tables or Code Lists in Part A, Part B or Part C of WMO-No. 306 Manual on Codes.

2.2 Code or vocabulary items are referenced from within XML documents using the xlink:href attribute [XML Linking Language (XLink) Version 1.1].

2.3 The target code table or vocabulary from which codes or vocabulary items shall, should or may be drawn is defined within the GML application schema using the //annotation/appinfo/vocabulary element within the XML Type definition.

2.4 The level of validation applied when assessing membership of codes or vocabulary items within the target code table or vocabulary is defined within the GML application schema using the //annotation/appinfo/extensibility element within the XML Type definition.

2.4.1 <extensibility> “none” indicates that codes or vocabulary items shall be drawn from the target code table or vocabulary.

2.4.2 <extensibility> “narrower” indicates that codes or vocabulary items shall be drawn from the target code table or vocabulary, or that the code or vocabulary item used shall be derived from another term within the target code table or vocabulary using a more refined, or narrower, definition.

2.4.3 <extensibility> “any” indicates that codes or vocabulary items may be drawn from the target code table, code list or vocabulary or any other code table or vocabulary deemed appropriate by the author.

2.5 Code or vocabulary items referenced from within GML documents should have an available online definition and have been recognised by some level of authority.

2.6 Each code list managed by WMO in support of XML application schemas shall have a unique identifier of the form: http://codes.wmo.int/<identifier>.

Note: The recommended practice for selecting <identifier> is to base it on the WMO Number of the document defining the appropriate regulation, and the table within that document. An example of a unique identifier is http://codes.wmo.int/306/4678/BLSN.

Note: WMO provides a web service that makes the unique references are "resolvable". That means that if unique identifier, such as http://codes.wmo.int/306/4678/BLSN, is entered as a URL into a browser the definition of the item corresponding to the unique reference is displayed.

3 TABLES AND CODE LISTS SUPPORTING THE WMO LOGICAL DATA MODEL

3.1 Application of Code Tables and Code Lists

Regulations specified in Code Tables or Code Lists in Part A, Part B or Part C of WMO-No. 306 Manual on Codes shall apply to the corresponding entries in code tables used within the GML application schemas defined in this Manual.

3.2 Nil Reasons

3.2.1 Nil reason terms from Part D code table D-1 shall, where permitted within the GML application schemas defined in this manual, be used to provide an explanation for recording a missing (or void) value within a GML document.

Note: Part D code table D-1 is described in Appendix A.

Note: Part D code table D-1 is published online at http://codes.wmo.int/common/nil.

3.2.2 Each nil reason term is identified with a URI [IETF RFC 3986 Uniform Resource Identifier (URI): Generic Syntax]. The URI shall comprise the “Code-space” column concatenated with the “Notation” column of Part D code table D-1.

3.3 Physical Quantities

3.3.1 Terms from Part D code Table D-2 shall be used within the GML application schemas defined in this Manual to describe physical quantity kinds.

3.3.2 Each physical quantity kind is identified with a URI [IETF RFC 3986 Uniform Resource Identifier (URI): Generic Syntax]. The URI shall comprise the path http://codes.wmo.int/common/quantity-kind concatenated with the value listed in the “Notation” column of Part D code Table -D-2: Physical quantity kinds.

4 REFERENCES

4.1 Normative References

Extensible Markup Language (XML) 1.0 (Second Edition), W3C Recommendation (6 October 2000)

XML Schema Part 1: Structures (Second Edition), W3C Recommendation (28 October 2004)

XML Schema Part 2: Datatypes (Second Edition), W3C Recommendation (28 October 2004)

Namespaces in XML 1.0 (Third Edition), W3C Recommendation (8 December 2009)

XML Linking Language (XLink) Version 1.1, W3C Recommendation (6 May 2010)

ISO/IEC 19757-3:2006, Information technology – Document Schema Definition Languages (DSDL) – Part 3: Rule-based validation – Schematron

ISO 8601:2004, Data elements and interchange formats – Information interchange – Representation of dates and times

ISO 19136:2007, Geographic information – Geography markup language (GML)

ISO/TS 19139:2007, Geographic information – Metadata – XML schema implementation

OGC/IS 08-094r1 SWE Common Data Model Encoding Standard 2.0

OGC/SAP 09-146r2 GML Application Schema – Coverages 1.0.1

OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation

4.2 Informative References

XML Path Language (XPath) 2.0 (Second Edition), W3C Recommendation (14 December 2010; correction 3 January 2011)

ISO 19103:2005 Geographic information – Conceptual schema language

ISO 19109:2005 Geographic information – Rules for application schema

ISO 19123:2005 Geographic information – Schema for coverage and geometry functions

ISO 19156:2011 Geographic information – Observations and measurements

IETF RFC 2387 MIME Multipart/Related Content Type (August 1998)

IETF RFC 3986 Uniform Resource Identifier (URI): Generic Syntax (January 2005)

FM-201: COLLECTION OF FEATURES

FM 201-15 EXT COLLECT-XML COLLECTION OF FEATURES

201.1 Scope

COLLECT-XML should be used to represent a collection of GML feature instances of the same type of meteorological information. The intent is to allow XML encoded meteorological information to be packaged in a way that emulates the existing data distribution practices used within the Global Telecommunication System (GTS) and Aeronautical Fixed System (AFS).

Note: the collection of meteorological information is often referred to as a bulletin.

Note: XML encodings of meteorological information are defined in Part D; for example FM 205-15 EXT IWXXM-XML.

Note: aggregation of meteorological information in form of meteorological bulletins usually takes place at a station or centre originating or compiling the bulletin, as agreed internationally. A meteorological bulletin may have one or more instances of meteorological information. If meteorological reports of routine messages are not available during compilation, a NIL report of that station should be included in the published contents of the bulletin.

The Requirements Classes defined in COLLECT-XML are listed in Table 1.

Table 1. Requirements Classes defined in COLLECT-XML

Requirements Classes	
Requirements Class	http://def.wmo.int/collect/2014/req/xsd-meteorological-bulletin, Part D, 201.3

201.2 XML Schema for COLLECT-XML

201.2.1 Representations of information in COLLECT-XML shall declare the XML namespaces listed in Table 2 and Table 3.

Note: additional namespace declarations may be required depending on the XML elements used within COLLECT-XML. In particular, the meteorological information included within the bulletin is likely to imply specific requirements regarding namespace declaration.

Note: Schematron schemas providing additional constraints are provided as an external file to the XSD defining COLLECT-XML. The canonical location of this file is: http://schemas.wmo.int/rule/1.1/collect.sch.

Table 2. XML namespaces defined for COLLECT-XML

XML Namespace	Default namespace prefix	Canonical location of all-components schema document
http://def.wmo.int/collect/2014	collect	http://schemas.wmo.int/collect/1.1/collect.xsd

Table 3. External XML namespaces used in COLLECT-XML

Standard	XML Namespace	Default namespace prefix	Canonical location of all-components schema document
XML Schema	http://www.w3.org/2001/XMLSchema	xs	
Schematron	http://purl.oclc.org/dsdl/schematron	sch	
XSLT v2	http://www.w3.org/1999/XSL/Transform	xsl	
XML Linking Language	http://www.w3.org/1999/xlink	xlink	
ISO 19136:2006 GML	http://www.opengis.net/gml/3.2	gml	http://schemas.opengis.net/gml/3.2.1/gml.xsd

201.3 Requirements Class: Meteorological bulletin

201.3.1 This requirements class is used to describe the collection of GML feature instances of meteorological information.

201.3.2 XML elements describing a meteorological bulletin shall conform to all Requirements specified in Table 4.

Table 4. Requirements class xsd-meteorological-bulletin

Requirements Class	
http://def.wmo.int/collect/2014/req/xsd-meteorological-bulletin	
Target Type	Data instance
Name	Meteorological bulletin
Requirement	http://def.wmo.int/collect/2014/req/xsd-meteorological-bulletin/valid The content model of this element shall have a value that matches the content model of collect:MeteorologicalBulletin.
Requirement	http://def.wmo.int/collect/2014/req/xsd-meteorological-bulletin/bulletin-identifier The value of XML element collect:MeteorologicalBulletin/bulletinIdentifier shall conform to the general file naming convention described in the Manual on the Global Telecommunication System (WMO No. 386), Attachment II-15.
Requirement	http://def.wmo.int/collect/2014/req/xsd-meteorological-bulletin/meteorological-information The XML element collect:MeteorologicalBulletin shall contain one or more child elements collect:MeteorologicalBulletin/collect:meteorologicalInformation, each of which shall contain one and only one child element expressing a report of meteorological information.
Requirement	http://def.wmo.int/collect/2014/req/xsd-meteorological-bulletin/consistent-meteorological-information-type An instance of collect:MeteorologicalBulletin shall contain only one type of meteorological information reports. All child elements of XML element collect:MeteorologicalBulletin/collect:meteorologicalInformation shall be of the same type, and hence have the same qualified name.

Note: in the context of the file naming convention, abbreviated headings are described in Manual on the Global Telecommunication System (WMO No. 386), Attachment II-15, 2.3.2.

Note: meteorological information reports include METAR, SPECI, TAF and SIGMET – represented using XML elements iwxxm:METAR, iwxxm:SPECI, iwxxm:TAF and iwxxm:SIGMET.

Note: the qualified name of a METAR is iwxxm:METAR which is of type iwxxm:METARType.

FM-202: METCE

FM 202-15 EXT METCE-XML FOUNDATION BUILDING BLOCKS

202.1 Scope

METCE-XML shall be used for the exchange in extensible markup language (XML) of meteorological information conforming to the “Modéle pour l’Échange des informations sur le Temps, le Climat et l’Eau.” (METCE) application schema. METCE-XML may be used directly to encode meteorological information or incorporated as components within other XML encodings.

Note: the METCE application schema is described in the informal document *Guidelines on Data Modelling for WMO Codes* (available in English only from http://wis.wmo.int/metce-uml).

The Requirements Classes defined in METCE-XML are listed in Table 5.

Table 5. Requirements Classes defined in METCE-XML

Requirements Classes	
Requirements Class	http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement, Part D, 202.4
Requirements Class	http://def.wmo.int/metce/2013/req/xsd-sampling-coverage-measurement, Part D, 202.5
Requirements Class	http://def.wmo.int/metce/2013/req/xsd-sampling-observation, Part D, 202.6
Requirements Class	http://def.wmo.int/metce/2013/req/xsd-volcano, Part D, 202.7
Requirements Class	http://def.wmo.int/metce/2013/req/xsd-erupting-volcano, Part D, 202.8
Requirements Class	http://def.wmo.int/metce/2013/req/xsd-tropical-cyclone, Part D, 202.9
Requirements Class	http://def.wmo.int/metce/2013/req/xsd-process, Part D, 202.10
Requirements Class	http://def.wmo.int/metce/2013/req/xsd-measurement-context, Part D, 202.11

202.2 XML Schema for METCE-XML

202.2.1 Representations of information in METCE-XML shall declare the XML namespaces listed in Table 6 and Table 7.

Note: additional namespace declarations may be required depending on the XML elements used within the METCE-XML.

Note: the XML Schema is packaged in three XML schema documents (XSD) describing one XML namespace: http://def.wmo.int/metce/2013.

Note: Schematron schemas providing additional constraints are embedded within the XSD defining METCE-XML.

Table 6. XML namespaces defined for METCE-XML

XML Namespace	Default namespace prefix	Canonical location of all-components schema document
http://def.wmo.int/metce/2013	metce	http://schemas.wmo.int/metce/1.1/metce.xsd

Table 7. External XML namespaces used in METCE-XML

Standard	XML Namespace	Default namespace prefix	Canonical location of all-components schema document
XML Schema	http://www.w3.org/2001/XMLSchema	xs	
Schematron	http://purl.oclc.org/dsdl/schematron	sch	
XSLT v2	http://www.w3.org/1999/XSL/Transform	xsl	
XML Linking Language	http://www.w3.org/1999/xlink	xlink	
ISO 19136:2006 GML	http://www.opengis.net/gml/3.2	gml	http://schemas.opengis.net/gml/3.2.1/gml.xsd
ISO/TS 19139:2007 metadata XML implementation	http://www.isotc211.org/2005/gmd	gmd	http://standards.iso.org/ittf/PubliclyAvailableStandards/ ISO_19139_Schemas/gmd/gmd.xsd
OGC OMXML	http://www.opengis.net/om/2.0	om	http://schemas.opengis.net/om/2.0/observation.xsd
OGC OMXML	http://www.opengis.net/samplingSpatial/2.0	sams	http://schemas.opengis.net/samplingSpatial/2.0/ spatialSamplingFeature.xsd
FM 203-15 Ext. OPM-XML	http://def.wmo.int/opm/2013	opm	http://schemas.wmo.int/opm/1.1/opm.xsd

202.3 Virtual typing

202.3.1 In accordance with OMXML (clause 7.2), the specialization of OM_Observation is provided through schematron restriction. The om:type element shall be used to specify the type of OM_Observation that is being encoded using the URI for the corresponding observation type listed in Part D code table D-3.

Note: Part D code Table D-3 is described in Part D Appendix A.

Note: Part D code table D-3 is published online at http://codes.wmo.int/common/observation-type/METCE/2013.

Note: the URI for each observation type is composed by appending the *notation* to the *code-space*. As an example, the URI of ComplexSamplingMeasurement is http://codes.wmo.int/common/observation-type/METCE/2013/ComplexSamplingMeasurement.

Note: Each URI will resolve to provide further information about the associated observation type.

Note: The terms “observation” and “measurement” evoke a particular concept to meteorologists (e.g. the measurement of a physical phenomena using an instrument or sensor). As defined in ISO 19156:2011, Geographic information – Observations and Measurements, an instance of OM_Observation is defined as an “estimate of the value of some property of some feature of interest using a specified procedure”. OM_Measurement is clearly applicable to the measurement of some physical property values using an instrument or sensor, but is equally applicable to the numerical simulation of physical property values using a computational model (e.g. a forecast or reanalysis).

202.4 Requirements Class: Complex Sampling Measurement

202.4.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the ‘result’ of the observation is a set of values relating to a specified location and time instant or duration, the ‘feature of interest’ is a representative subset of the atmosphere or body of water etc. based on a predetermined sampling regime and the ‘procedure’ provides the set of information as specified by WMO.

Note: ComplexSamplingMeasurement (a subclass of OM_ComplexObservation) is intended for use where the observation event is concerned with the evaluation of multiple measurands at a specified location and time instant or duration. OM_ComplexObservation is used because the 'result' of this class of observations is a group of measures, provided as a Record (as defined in ISO 19103:2005 Geographic information – Conceptual schema language).

202.4.2 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/common/observation-type/METCE/2013/ComplexSamplingMeasurement shall conform to all Requirements specified in Table 8.

202.4.3 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/common/observation-type/METCE/2013/ComplexSamplingMeasurement shall conform to all Requirements of all relevant dependencies specified in Table 8.

Note: XML implementation of metce:ComplexSamplingMeasurement is dependent on:

OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation]

SWE Common 2.0 [OGC/IS 08-094r1 SWE Common Data Model Encoding Standard 2.0]

Table 8. Requirements class xsd-complex-sampling-measurement

Requirements Class	
http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement	
Target Type	Data instance
Name	Complex sampling measurement
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation, OMXML clause 7.3
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/complexObservation, OMXML clause 7.10
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/sampling, OMXML clause 7.14
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling, OMXML clause 7.15
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components, SWE Common 2.0 clause 8.1
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-record-components, SWE Common 2.0 clause 8.2
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-encodings, SWE Common 2.0 clause 8.5
Dependency	http://www.opengis.net/spec/SWE/2.0/req/general-encoding-rules, SWE Common 2.0 clause 9.1
Dependency	http://www.opengis.net/spec/SWE/2.0/req/text-encoding-rules, SWE Common 2.0 clause 9.2
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xml-encoding-rules, SWE Common 2.0 clause 9.3
Requirement	http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement/xmlns-declaration-swe The OGC SWE Common 2.0 namespace http://www.opengis.net/swe/2.0 shall be declared within the XML document.
Requirement	http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement/procedure-metce-process The XML element om:procedure shall contain a child element metce:Process or any element of a substitution group of metce:Process.
Recommendation	The default namespace prefix used for http://www.opengis.net/swe/2.0 should be “swe”.

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/observation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/observation (OMXML clause A.1).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/complexObservation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/complexObservation (OMXML clause A.8).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/sampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/sampling (OMXML clause A.12).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/spatialSampling (OMXML clause A.13).

Note: dependency http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xsd-simple-components (SWE Common 2.0 clause A.8).

Note: dependency http://www.opengis.net/spec/SWE/2.0/req/xsd-record-components has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xsd-record-components (SWE Common 2.0 clause A.9).

Note: dependency http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-encodings has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xsd-simple-encodings (SWE Common 2.0 clause A.12).

Note: dependency http://www.opengis.net/spec/SWE/2.0/req/general-encoding-rules has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/general-encoding-rules (SWE Common 2.0 clause A.14).

Note: dependency http://www.opengis.net/spec/SWE/2.0/req/text-encoding-rules has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/text-encoding-rules (SWE Common 2.0 clause A.15).

Note: dependency http://www.opengis.net/spec/SWE/2.0/req/xml-encoding-rules has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xml-encoding-rules (SWE Common 2.0 clause A.16).

Note: the canonical schema location for OGC SWE Common 2.0 (http://www.opengis.net/swe/2.0) is http://schemas.opengis.net/sweCommon/2.0/swe.xsd.

202.5 Requirements Class: Sampling Coverage Measurement

202.5.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the ‘result’ of the observation is a set of values describing the variation of properties with space and/or time, the ‘feature of interest’ is a representative subset of the atmosphere or body of water etc. based on a predetermined sampling regime and the ‘procedure’ provides the set of information as specified by WMO.

Note: SamplingCoverageMeasurement (a subclass of OM_DiscreteCoverageObservation) is intended for use where the observation event is concerned with the evaluation of measurands that vary with respect to space and/or time. OM_DiscreteCoverageObservation is used because the 'result' of this class of observations is a discrete coverage (as defined in ISO 19123:2005 Geographic information – Schema for coverage and geometry functions).

Note: SamplingCoverageMeasurement is based on the informative SamplingCoverageObservation specialization of OM_Observation outlined in ISO 19156:2011 clause D.3.4. Within METCE, additional restrictions are applied to the 'procedure'. Furthermore, the name is changed from "SamplingCoverageObservation" to "SamplingCoverageMeasurement" in an attempt to disambiguate the two classes and to mitigate confusion arising from use of the term "observation".

202.5.2 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/common/observation-type/METCE/2013/SamplingCoverageMeasurement shall conform to all Requirements specified in Table 9.

202.5.3 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/common/observation-type/METCE/2013/SamplingCoverageMeasurement shall conform to all Requirements of all relevant dependencies specified in Table 9.

Note: XML implementation of metce:ComplexSamplingMeasurement is dependent on:

OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation]

SWE Common 2.0 [OGC/IS 08-094r1 SWE Common Data Model Encoding Standard 2.0]

GMLCOV 1.0 [OGC/SAP 09-146r2 GML Application Schema – Coverages 1.0.1]

Table 9. Requirements class xsd-sampling-coverage-measurement

Requirements Class	
http://def.wmo.int/metce/2013/req/xsd-sampling-coverage-measurement	
Target Type	Data instance
Name	Sampling coverage measurement
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation, OMXML clause 7.3
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/sampling, OMXML clause 7.14
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling, OMXML clause 7.15
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components, SWE Common 2.0 clause 8.1
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-record-components, SWE Common 2.0 clause 8.2
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-block-components, SWE Common 2.0 clause 8.4
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-encodings, SWE Common 2.0 clause 8.5

Requirements Class	
Dependency	http://www.opengis.net/spec/SWE/2.0/req/general-encoding-rules, SWE Common 2.0 clause 9.1
Dependency	http://www.opengis.net/spec/SWE/2.0/req/text-encoding-rules, SWE Common 2.0 clause 9.2
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xml-encoding-rules, SWE Common 2.0 clause 9.3
Dependency	http://www.opengis.net/spec/gmlcov/1.0/req/gml-coverage, GMLCOV 1.0 clause 6
Dependency	http://www.opengis.net/spec/gmlcov/1.0/req/gml, GMLCOV 1.0 clause 7
Requirement	http://def.wmo.int/metce/2013/req/xsd-sampling-coverage-measurement/xmlns-declaration-swe The OGC SWE Common 2.0 namespace http://www.opengis.net/swe/2.0 shall be declared within the XML document.
Requirement	http://def.wmo.int/metce/2013/req/xsd-sampling-coverage-measurement/xmlns-declaration-gmlcov The OGC GMLCOV 1.0 namespace http://www.opengis.net/gmlcov/1.0 shall be declared within the XML document.
Requirement	http://def.wmo.int/metce/2013/req/xsd-sampling-coverage-measurement/result-discrete-or-grid-coverage The XML element om:result shall contain a child element gml:DiscreteCoverage (or any element of a substitution group of gml:DiscreteCoverage), gml:GridCoverage, gml:RectifiedGridCoverage or gml:ReferenceableGridCoverage.
Requirement	http://def.wmo.int/metce/2013/req/xsd-sampling-coverage-measurement/result-coverage-gml-encoding The child element of om:result shall be represented in GML as defined in GMLCOV 1.0 clause 7. Multipart representation and special format representation shall not be used.
Requirement	http://def.wmo.int/metce/2013/req/xsd-sampling-coverage-measurement/procedure-metce-process The XML element om:procedure shall contain a child element metce:Process or any element of a substitution group of metce:Process.
Recommendation	The default namespace prefix used for http://www.opengis.net/swe/2.0 should be “swe”.
Recommendation	The default namespace prefix used for http://www.opengis.net/gmlcov/1.0 should be “gmlcov”.

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/observation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/observation (OMXML clause A.1).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/sampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/sampling (OMXML clause A.12).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/spatialSampling (OMXML clause A.13).

Note: dependency http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xsd-simple-components (SWE Common 2.0 clause A.8).

Note: dependency http://www.opengis.net/spec/SWE/2.0/req/xsd-record-components has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xsd-record-components (SWE Common 2.0 clause A.9).

Note: dependency http://www.opengis.net/spec/SWE/2.0/req/xsd-block-components has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xsd-block-components (SWE Common 2.0 clause A.11).

Note: dependency http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-encodings has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xsd-simple-encodings (SWE Common 2.0 clause A.12).

Note: dependency http://www.opengis.net/spec/SWE/2.0/req/general-encoding-rules has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/general-encoding-rules (SWE Common 2.0 clause A.14).

Note: dependency http://www.opengis.net/spec/SWE/2.0/req/text-encoding-rules has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/text-encoding-rules (SWE Common 2.0 clause A.15).

Note: dependency http://www.opengis.net/spec/SWE/2.0/req/xml-encoding-rules has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xml-encoding-rules (SWE Common 2.0 clause A.16).

Note: the canonical schema location for OGC SWE Common 2.0 (http://www.opengis.net/swe/2.0) is http://schemas.opengis.net/sweCommon/2.0/swe.xsd.

Note: dependency http://www.opengis.net/spec/gmlcov/1.0/req/gml-coverage has associated conformance class (GMLCOV 1.0 clause A.1)

Note: dependency http://www.opengis.net/spec/gmlcov/1.0/req/gml has associated conformance class (GMLCOV 1.0 clause A.2)

Note: the canonical schema location for OGC GMLCOV 1.0 (http://www.opengis.net/gmlcov/1.0) is http://schemas.opengis.net/gmlcov/1.0/gmlcovAll.xsd.

202.6 Requirements Class: Sampling Observation

202.6.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the ‘feature of interest’ is a representative subset of the atmosphere

or body of water etc. based on a predetermined sampling regime and the 'procedure' provides the set of information as specified by WMO.

Note: SamplingObservation (a subclass of OM_Observation) is the most flexible of the three observation specializations defined in METCE as it adds no additional constraints on the type of the 'result'.

202.6.2 Where the semantics of one's application are appropriate, ComplexSamplingMeasurement or SamplingCoverageMeasurement should be used in preference to SamplingObservation as it is anticipated that software applications will be more readily able to parse and process data conforming to the former two observation types due to their more structured 'result' types.

202.6.3 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/common/observation-type/METCE/2013/SamplingObservation shall conform to all Requirements specified in Table 10.

202.6.4 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/common/observation-type/METCE/2013/SamplingObservation shall conform to all Requirements of all relevant dependencies specified in Table 10.

Note: XML implementation of metce:SamplingObservation is dependent on:

OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation]

Table 10. Requirements class xsd-sampling-observation

Requirements Class	
http://def.wmo.int/metce/2013/req/xsd-sampling-observation	
Target Type	Data instance
Name	Sampling observation
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation, OMXML clause 7.3
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/sampling, OMXML clause 7.14
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling, OMXML clause 7.15
Requirement	http://def.wmo.int/metce/2013/req/xsd-sampling-observation/procedure-metce-process The XML element om:procedure shall contain a child element metce:Process or any element of a substitution group of metce:Process.

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/observation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/observation (OMXML clause A.1).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/sampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/sampling (OMXML clause A.12).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/spatialSampling (OMXML clause A.13).

202.7 Requirements Class: Volcano

202.7.1 This requirements class is used to describe the representation of a volcano. The class is targeted at providing a basic description of the volcano as a meteorological phenomenon.

Note: representations providing more detailed information may be used if required.

202.7.2 XML elements describing volcanoes shall conform to all Requirements specified in Table 11.

Table 11. Requirements class xsd-volcano

Requirements Class	
http://def.wmo.int/metce/2013/req/xsd-volcano	
Target Type	Data instance
Name	Volcano
Requirement	http://def.wmo.int/metce/2013/req/xsd-volcano/valid The content model of this element shall have a value that matches the content model of metce:Volcano.
Requirement	http://def.wmo.int/metce/2013/req/xsd-volcano/name The XML element metce:name shall provide an authoritative name for the given volcano as a literal character string.
Requirement	http://def.wmo.int/metce/2013/req/xsd-volcano/position The XML element metce:position shall contain a valid child element gml:Point that provides the reference location of the volcano in question.
Recommendation	http://def.wmo.int/metce/2013/req/xsd-volcano/name-as-block-caps The authoritative name for the given volcano should be expressed in block capitals.

Note: the Global Volcanism Program provides an online, searchable catalogue of volcanoes which may assist in identifying the authoritative name for a given volcano. The catalogue is accessed at the URL http://www.volcano.si.edu/world/. No guarantee is made regarding the availability of this catalogue service.

202.8 Requirements Class: Erupting volcano

202.8.1 This requirements class is used to describe the representation of a currently erupting, or recently erupted, volcano, that is the source of volcanic ash or other significant meteorological phenomena described in weather reports.

Note: representations providing more detailed information may be used if required.

202.8.2 XML elements describing volcanoes where the date of a particular eruption is deemed important shall conform to all Requirements specified in Table 12.

202.8.2 XML elements describing volcanoes where the date of a particular eruption is deemed important shall conform to all Requirements of all relevant dependencies specified in Table 12.

Table 12. Requirements class xsd-erupting-volcano

Requirements Class	
http://def.wmo.int/metce/2013/req/xsd-erupting-volcano	
Target Type	Data instance
Name	Erupting volcano
Dependency	http://def.wmo.int/metce/2013/req/xsd-volcano
Requirement	http://def.wmo.int/metce/2013/req/xsd-erupting-volcano/valid The content model of this element shall have a value that matches the content model of metce:EruptingVolcano.
Requirement	http://def.wmo.int/metce/2013/req/xsd-erupting-volcano/eruption-date The XML element metce:eruptionDate shall provide the date at which the current or recent eruption began expressed in ISO 8601 date-time format.

202.9 Requirements Class: Tropical cyclone

202.9.1 This requirements class is used to describe the representation of a tropical cyclone.

Note: in this release of METCE-XML, the information expressed about a tropical cyclone is limited to the cyclone's name. Representations providing more detailed information may be used if required.

202.9.2 XML elements describing tropical cyclones shall conform to all Requirements specified in Table 13.

Table 13. Requirements class xsd-tropical-cyclone

Requirements Class	
http://def.wmo.int/metce/2013/req/xsd-tropical-cyclone	
Target Type	Data instance
Name	Tropical cyclone
Requirement	http://def.wmo.int/metce/2013/req/xsd-tropical-cyclone/valid The content model of this element shall have a value that matches the content model of metce:TropicalCyclone.
Requirement	http://def.wmo.int/metce/2013/req/xsd-tropical-cyclone/name The XML element metce:name shall provide an authoritative name for the given tropical cyclone as a literal character string.
Recommendation	http://def.wmo.int/metce/2013/req/xsd-tropical-cyclone/name-as-block-caps The authoritative name for the given tropical cyclone should be expressed in block capitals.

202.10 Requirements Class: Process

202.10.1 This requirements class is used to describe the procedures involved in generating an observation or measurement.

Note: Process provides a concrete implementation of the abstract OM_Process class.

Note: an instance of Process is often an instrument or sensor (perhaps even a sensor in a given calibrated state), but it may be a human observer executing a set of repeatable instructions, a simulator or a process algorithm.

Note: Process is intended to allow the provision of reference(s) to supporting documentation (e.g. online documentation describing the procedure in detail) plus the resolution (e.g. the smallest quantity being measured that causes a perceptible change in the corresponding indication) and measuring interval (e.g. the range of values for a given quantity kind that an instrument or sensor can detect under the defined conditions) for each physical quantity kind observed.

Note: Process is targeted at providing a basic process description; representations providing more detailed information may be used.

202.10.2 An instance of Process should provide sufficient information for one to interpret the result of an observation.

Note: the recalibration of a sensor such as an anemometer, or modifying its height above local ground, is likely to affect the values that that sensor records; a new instance of Process may be required to express such changes enabling accurate interpretation of the observation result.

202.10.3 XML elements describing procedures relating to observations or measurements shall conform to all Requirements specified in Table 14.

Table 14. Requirements class xsd-process

Requirements Class	
http://def.wmo.int/metce/2013/req/xsd-process	
Target Type	Data instance
Name	Process
Requirement	http://def.wmo.int/metce/2013/req/xsd-process/valid The content model of this element shall have a value that matches the content model of metce:Process.
Recommendation	http://def.wmo.int/metce/2013/req/xsd-process/description A description of the procedure, or citation to some well known description of the procedure, should be provided using the gml:description element.
Recommendation	http://def.wmo.int/metce/2013/req/xsd-process/documentation-reference Where more information about the procedure is accessible online, a reference to that information should be provided using the xlink:href attribute of the metce:documentationRef element to indicate the URL of the online documentation.
Recommendation	http://def.wmo.int/metce/2013/req/xsd-process/configuration Where more information about the procedure configuration is available, such as details of a sensor's calibration or deployment environment, that information should be included in the procedure description. For each configuration item, an XML element metce:parameter shall be provided, each with a child element om:NamedValue. XML element //metce:parameter/om:NamedValue/om:name shall indicate the meaning of the parameter. The parameter name should be taken from a well-governed source. Furthermore, to avoid ambiguity, there should be no more than one parameter with the same name within a given procedure description. XML element //metce:parameter/om:NamedValue/om:value provides the value of the parameter using any suitable concrete type.
Recommendation	http://def.wmo.int/metce/2013/req/xsd-process/measurement-context Where additional information about the quantity kind(s) observed or measured by the procedure, such as qualification or constraint of the quantity kind, or details of the resolution and/or range with which the procedure is able to measure a given quantity kind is available, that information should be included in the procedure description. For each quantity kind that additional information is to be provided for, an XML element metce:context should be provided, each with a child element metce:MeasurementContext (or any element of a substitution group of metce:MeasurementContext).

Note: where a procedure is common for many observations, the metce:Process describing that procedure may be published online at an accessible location and referenced from each observation using xlink:href to indicate the URL.

202.11 Requirements Class: Measurement context

202.11.1 This requirements class is used to describe the additional context that may be provided for a quantity kind measured by a given procedure.

Note: the measurement context allows the resolution scale (e.g. the smallest change in quantity being measure that causes a perceptible change in the corresponding indication) and/or the measuring interval (e.g. the range of values that can be measured) to be defined for a given quantity kind for the associated procedure. For example, it is possible to state that a given procedure, say a thermometer, is able to measure air temperature to a resolution of 0.5 degree Celsius in the range -30 degree Celsius to +50 degree Celsius.

202.11.2 XML elements describing procedures relating to observations or measurements shall conform to all Requirements specified in Table 15.

Table 15. Requirements class xsd-measurement-context

Requirements Class	
http://def.wmo.int/metce/2013/req/xsd-measurement-context	
Target Type	Data instance
Name	Measurement context
Dependency	http://def.wmo.int/opm/2013/req/xsd-observable-property, Part D, 203.3
Requirement	http://def.wmo.int/metce/2013/req/xsd-measurement-context/valid The content model of this element shall have a value that matches the content model of metce:MeasurementContext.
Requirement	http://def.wmo.int/metce/2013/req/xsd-measurement-context/measurand The quantity kind to which this element applies shall be specified via the XML element metce:measurand.
Requirement	http://def.wmo.int/metce/2013/req/xsd-measurement-context/unit-of-measure-consistent The unit of measurement specified in XML element metce:unitOfMeasure shall be consistent with the unit of measurement used to express resolution scale and/or measuring interval.

Requirements Class	
Requirement	http://def.wmo.int/metce/2013/req/xsd-measurement-context/unit-of-measure-provision Where either XML elements metce:resolutionScale or metce:measuringInterval or both are present, XML element metce:unitOfMeasure shall be provided.
Requirement	http://def.wmo.int/metce/2013/req/xsd-measurement-context/measuring-interval-range-bounds-order Where the measuring interval is specified, the lower limit of the interval, expressed via XML element //metce:measuringInterval/metce:RangeBounds/metce:rangeStart, shall be less than the upper limit of the interval, expressed via XML element //metce:measuringInterval/metce:RangeBounds/metce:rangeEnd.

Note: the XML element metce:measurand may reference a quantity kind provided by some authority using xlink:href to indicate the URI of the quantity kind, or provide a child element opm:ObservableProperty (or element within the substitution group of opm:ObservableProperty). The latter case may be useful where additional qualification or constraint relating to the quantity kind needs to be embedded within the GML document as XML element //om:OM_Observation/om:observedProperty only permits the observed quantity kind to be expressed by reference using xlink:href.

Note: units of measurement are specified in accordance with Part D, 1.9.

FM-203: OPM

FM 203-15 EXT OPM-XML OBSERVABLE PROPERTY MODEL

203.1 Scope

OPM-XML should be used to represent complex observable properties (also known as "quantity kinds") where individual observable properties are aggregated into groups or where the qualification and/or constraint applied to an observable property needs to be explicitly described.

Note: an "observable property" is a physical property that can be observed; typically this will be a quantitative property, such as dew point temperature.

Note: OPM, the Observable Property Model, was developed to a draft level by the Open Geospatial Consortium Sensor Web Enablement Working Group and was re-used in the INSPIRE Generic Conceptual Model. It is published by WMO to ensure that there is a stable definition of its XML schemas.

Note: the Observable Property Model application schema is described in the *Guidelines for data modelling for WMO codes* (available in English only from http://wis.wmo.int/metce-uml).

The Requirements Classes defined in OPM-XML are listed in Table 16.

Table 16. Requirements Classes defined in OPM-XML

Requirements Classes	
Requirements Class	http://def.wmo.int/opm/2013/req/xsd-observable-property, Part D, 203.3
Requirements Class	http://def.wmo.int/opm/2013/req/xsd-composite-observable-property, Part D, 203.4
Requirements Class	http://def.wmo.int/opm/2013/req/xsd-qualified-observable-property, Part D, 203.5
Requirements Class	http://def.wmo.int/opm/2013/req/xsd-statistical-qualifier, Part D, 203.6
Requirements Class	http://def.wmo.int/opm/2013/req/xsd-constraint, Part D, 203.7
Requirements Class	http://def.wmo.int/opm/2013/req/xsd-category-constraint, Part D, 203.8
Requirements Class	http://def.wmo.int/opm/2013/req/xsd-scalar-constraint, Part D, 203.9
Requirements Class	http://def.wmo.int/opm/2013/req/xsd-range-constraint, Part D, 203.10

203.2 XML Schema for OPM-XML

203.2.1 Representations of information in OPM-XML shall declare the XML namespaces listed in Table 17 and Table 18.

Note: additional namespace declarations may be required depending on the XML elements used within OPM-XML.

Note: the XML Schema is packaged in two XML schema documents (XSD) describing one XML namespace: http://def.wmo.int/opm/2013.

Note: Schematron schemas providing additional constraints are embedded within the XSD defining OPM-XML.

Table 17. XML namespaces defined for OPM-XML

XML Namespace	Default namespace prefix	Canonical location of all-components schema document
http://def.wmo.int/opm/2013	opm	http://schemas.wmo.int/opm/1.1/opm.xsd

Table 18. External XML namespaces used in OPM-XML

Standard	XML Namespace	Default namespace prefix	Canonical location of all-components schema document
XML Schema	http://www.w3.org/2001/XMLSchema	xs	
Schematron	http://purl.oclc.org/dsdl/schematron	sch	
XSLT v2	http://www.w3.org/1999/XSL/Transform	xsl	
XML Linking Language	http://www.w3.org/1999/xlink	xlink	
ISO 19136:2006 GML	http://www.opengis.net/gml/3.2	gml	http://schemas.opengis.net/gml/3.2.1/gml.xsd

203.3 Requirements Class: Observable property

203.3.1 This requirements class is used to describe the representation of an observable property.

Note: representations providing more detailed information – such as composite observable property and qualified observable property (see 203.4 and 203.5 below) – may be used if required.

203.3.2 XML elements describing observable properties shall conform to all Requirements specified in Table 19.

Table 19. Requirements class xsd-observable-property

Requirements Class	
http://def.wmo.int/opm/2013/req/xsd-observable-property	
Target Type	Data instance
Name	Observable property
Requirement	http://def.wmo.int/opm/2013/req/xsd-observable-property/valid The content model of this element shall have a value that matches the content model of opm:AbstractObservableProperty.
Recommendation	http://def.wmo.int/opm/2013/req/xsd-observable-property/label The primary human-readable label for the observable property should be specified using the opm:label XML element.

Note: alternative human-readable labels may be specified using one or more instances of the XML element opm:altLabel.

Note: the XML element opm:notation may be used to specify a notation or code-value that is used to identify the observable property within a given context (e.g. providing a local identifier).

203.4 Requirements Class: Composite observable property

203.4.1 This requirements class is used to describe the representation of an aggregate set of observable properties.

203.4.2 XML elements describing composite observable properties shall conform to all Requirements specified in Table 20.

203.4.3 XML elements describing composite observable properties shall conform to all Requirements of all relevant dependencies specified in Table 20.

Table 20. Requirements class xsd-composite-observable-property

Requirements Class	
http://def.wmo.int/opm/2013/req/xsd-composite-observable-property	
Target Type	Data instance
Name	Composite observable property
Dependency	http://def.wmo.int/opm/2013/req/xsd-observable-property, Part D, 203.3

Requirements Class	
Requirement	http://def.wmo.int/opm/2013/req/xsd-composite-observable-property/valid The content model of this element shall have a value that matches the content model of opm:CompositeObservableProperty.
Requirement	http://def.wmo.int/opm/2013/req/xsd-composite-observable-property/set A composite observable property shall contain a minimum of 2 child observable properties.
Requirement	http://def.wmo.int/opm/2013/req/xsd-composite-observable-property/child-property For each child observable property within the composite observable property, the XML element //opm:CompositeObservableProperty/opm:property shall either contain a valid child element in the substitution group of opm:AbstractObservableProperty or provide a reference to the definition of the child observable property using the xlink:href attribute to indicate the URL where a description is located.
Requirement	http://def.wmo.int/opm/2013/req/xsd-composite-observable-property/count The XML attribute //opm:CompositeObservableProperty/@count shall specify the number of child observable properties from which the composite observable property is comprised.

Note: a child observable property specified within a composite observable property instance may itself be a composite observable property, thus allowing arbitrarily complex nesting of sets of observable properties.

203.5 Requirements Class: Qualified observable property

203.5.1 This requirements class is used to describe the representation of an observable property subject to additional qualification or constraint.

Note: the observable property to which the additional qualification or constraint is applied is known as the base property.

203.5.2 XML elements describing qualified observable properties shall conform to all Requirements specified in Table 21.

203.5.3 XML elements describing qualified observable properties shall conform to all Requirements of all relevant dependencies specified in Table 21.

Table 21. Requirements class xsd-qualified-observable-property

Requirements Class	
http://def.wmo.int/opm/2013/req/xsd-qualified-observable-property	
Target Type	Data instance
Name	Qualified observable property
Dependency	http://def.wmo.int/opm/2013/req/xsd-observable-property, Part D, 203.3
Requirement	http://def.wmo.int/opm/2013/req/xsd-qualified-observable-property/valid The content model of this element shall have a value that matches the content model of opm:QualifiedObservableProperty.
Requirement	http://def.wmo.int/opm/2013/req/xsd-qualified-observable-property/base-property The XML element //opm:QualifiedObservableProperty/opm:baseProperty shall either contain a valid child element opm:ObservableProperty (or element within the substitution group of opm:ObservableProperty) that describes the base property or provide a reference to the definition of the base property using the xlink:href attribute to indicate the URL where a description is located.
Requirement	http://def.wmo.int/opm/2013/req/xsd-qualified-observable-property/specified-unit-of-measure If the base property is qualified such that values of the qualified observable property are always provided using a given unit of measurement, the XML attribute //opm:QualifiedObservableProperty/opm:unitOfMeasure/@uom shall be used to specify that unit of measurement.
Requirement	http://def.wmo.int/opm/2013/req/xsd-qualified-observable-property/valid-unit-of-measure If specified, the unit of measurement referenced via XML attribute //opm:QualifiedObservableProperty/opm:unitOfMeasure/@uom shall be appropriate for the base property.
Requirement	http://def.wmo.int/opm/2013/req/xsd-qualified-observable-property/qualifier If specified, the XML element //opm:QualifiedObservableProperty/opm:qualifier shall contain a valid child element opm:StatisticalQualifier that provides details of any statistical qualification applied to the base property.

Requirements Class	
Requirement	http://def.wmo.int/opm/2013/req/xsd-qualified-observable-property/constraint If specified, the XML element //opm:QualifiedObservableProperty/opm:constraint shall contain a valid child element opm:Constraint, or element in the substitution group of opm:Constraint, that provides details of any constraint applied to the base property.
Recommendation	http://def.wmo.int/opm/2013/req/xsd-qualified-observable-property/minimal-qualification At least one of the XML elements //opm:QualifiedObservableProperty/opm:unitOfMeasure, //opm:QualifiedObservableProperty/opm:qualifier or //opm:QualifiedObservableProperty/opm:constraint should be included within a qualified observable property.

Note: units of measurement are specified in accordance with Part D, 1.9.

203.6 Requirements Class: Statistical qualifier

203.6.1 This requirements class is used to describe the representation of statistical qualifiers applied to an observable property.

Note: typically statistical qualification is based on some geometric or temporal aggregation using a given statistical function; for example, the maximum temperature in a 24-hour duration.

203.6.2 XML elements describing statistical qualification of observable properties shall conform to all Requirements specified in Table 22.

Table 22. Requirements class xsd-statistical-qualifier

Requirements Class	
http://def.wmo.int/opm/2013/req/xsd-statistical-qualifier	
Target Type	Data instance
Name	Statistical qualifier
Requirement	http://def.wmo.int/opm/2013/req/xsd-statistical-qualifier/valid The content model of this element shall have a value that matches the content model of opm:StatisticalQualifier.

Requirements Class	
Requirement	http://def.wmo.int/opm/2013/req/xsd-statistical-qualifier/statistical-function-code The XML element //opm:StatisticalQualifier/opm:statisticalFunction shall reference the function used in the statistical qualification using the xlink:href attribute to specify the URI used to identify the target statistical function.
Requirement	http://def.wmo.int/opm/2013/req/xsd-statistical-qualifier/single-qualification-domain One, and only one, of XML elements //opmStatisticalQualifier/opm:aggregationArea, //opmStatisticalQualifier/opm:aggregationLength, //opmStatisticalQualifier/opm:aggregationTimePeriod, //opmStatisticalQualifier/opm:aggregationVolume and //opmStatisticalQualifier/opm:otherAggregation shall be included within a statistical qualification.
Recommendation	http://def.wmo.int/opm/2013/req/xsd-statistical-qualifier/description A textual description of the statistical qualification applied to the observable property should be provided using the //opmStatisticalQualifier/opm:description XML element.
Recommendation	http://def.wmo.int/opm/2013/req/xsd-statistical-qualifier/statistical-function-code-online-definition The URI used to identify the statistical function should have an available online definition and have been recognised by some level of authority.
Recommendation	http://def.wmo.int/opm/2013/req/xsd-statistical-qualifier/qualification-domain-type Where the statistical qualification domain relates to geometric area, geometric length, time period or geometric volume then XML elements //opmStatisticalQualifier/opm:aggregationArea, //opmStatisticalQualifier/opm:aggregationLength, //opmStatisticalQualifier/opm:aggregationTimePeriod or //opmStatisticalQualifier/opm:aggregationVolume should be used in preference to XML element //opmStatisticalQualifier/opm:otherAggregation to describe the statistical qualification domain.

Note: groups of statistical qualifiers may be applied to a given base property; in such a case the order of the statistical qualification is important. For example, mean daily maximum temperature over a month period comprises two statistical operations with respect to the base property “air temperature” – a maximum over a 24-hour duration followed by a mean over a 1-month duration. A collection of statistical qualifiers can be linked using the XML element //opmStatisticalQualifier/opm:derivedFrom to establish an ordered set.

Note: terms from Part B, FM 92 GRIB Code table 4.10, Type of statistical processing, may be use used to describe the statistical function. An alternative source of statistical function codes are

provided in Part B, FM 94 BUFR Code table 0 08 023, First-order statistics. For convenience, these code tables have been published online at http://codes.wmo.int/grib2/codeflag/4.10 and http://codes.wmo.int/bufr4/codeflag/0-08-023 respectively.

203.7 Requirements Class: Constraint

203.7.1 This requirements class is used to describe the representation of constraints applied to an observable property.

Note: the observable property that is used to constrain the base property is known as the constraining property. For example, the observed property "radiance" may be constrained such that one is concerned only with the radiance between wavelengths 50nm to 100nm – in which case the constraining property is "wavelength".

Note: representations providing more detail – such as scalar constraint, range constraint or category constraint – may be used if required.

203.7.2 XML elements describing the constraint of observable properties shall conform to all Requirements specified in Table 23.

Table 23. Requirements class xsd-constraint

Requirements Class	
http://def.wmo.int/opm/2013/req/xsd-constraint	
Target Type	Data instance
Name	Constraint
Requirement	http://def.wmo.int/opm/2013/req/xsd-constraint/valid The content model of this element shall have a value that matches the content model of opm:Constraint.
Requirement	http://def.wmo.int/opm/2013/req/xsd-constraint/constraint-property The XML element opm:constraintProperty shall either contain a valid child element opm:ObservableProperty (or element within the substitution group of opm:ObservableProperty) that describes the constraining property or provide a reference to the definition of the constraining property using the xlink:href attribute to indicate the URL where a description is located.
Recommendation	http://def.wmo.int/opm/2013/req/xsd-constraint/description A textual description of the constraint applied to the observable property should be provided using the opm:description XML element.

203.8 Requirements Class: Category constraint

203.8.1 This requirements class is used to describe the representation of category-based constraints applied to an observable property.

Note: for example, where one is interested only in the cloud-base height of convective clouds, the base property is “cloud-base height”, the constraining property is “cloud type” and the values of the category constraint element list the particular cloud types of interest (e.g. cumulonimbus, towering cumulus etc.).

203.8.2 XML elements describing a category-based constraint of observable properties shall conform to all Requirements specified in Table 24.

203.8.3 XML elements describing a category-based constraint of observable properties shall conform to all Requirements of all relevant dependencies specified in Table 24.

Table 24. Requirements class xsd-category-constraint

Requirements Class	
http://def.wmo.int/opm/2013/req/xsd-category-constraint	
Target Type	Data instance
Name	Category constraint
Dependency	http://def.wmo.int/opm/2013/req/xsd-constraint, Part D, 203.7
Requirement	http://def.wmo.int/opm/2013/req/xsd-category-constraint/valid The content model of this element shall have a value that matches the content model of opm:CategoryConstraint.
Requirement	http://def.wmo.int/opm/2013/req/xsd-category-constraint/category-member One or more instances of the XML element //opm:CategoryConstraint/opm:value shall be used to specify the category members relevant to this constraint.
Requirement	http://def.wmo.int/opm/2013/req/xsd-category-constraint/category-member-appropriate-to-constraining-property Each of the category members defined using XML element //opm:CategoryConstraint/opm:value shall appropriate to the constraining property.
Recommendation	http://def.wmo.int/opm/2013/req/xsd-category-constraint/category-value-code-space The XML attribute //opm:CategoryConstraint/opm:value/@gml:codeSpace should be provided when specifying each category member.
Recommendation	http://def.wmo.int/opm/2013/req/xsd-category-constraint/category-value-online-definition Appending the content of the XML element //opm:CategoryConstraint/opm:value to the content of XML attribute //opm:CategoryConstraint/opm:value/@gml:codeSpace should create a URI that resolves to an online definition that is recognised by some authority.

203.9 Requirements Class: Scalar constraint

203.9.1 This requirements class is used to describe the representation of scalar constraints applied to an observable property.

Note: for example, the base property “air temperature” may be constrained such that one is concerned only with air temperature at 1.2 metres above the local ground level (e.g. a screen temperature); height above local ground level is the constraining property.

203.9.2 XML elements describing the constraint of observable properties shall conform to all Requirements specified in Table 25.

203.9.3 XML elements describing the constraint of observable properties shall conform to all Requirements of all relevant dependencies specified in Table 25.

Table 25. Requirements class xsd-scalar-constraint

Requirements Class	
http://def.wmo.int/opm/2013/req/xsd-scalar-constraint	
Target Type	Data instance
Name	Scalar constraint
Dependency	http://def.wmo.int/opm/2013/req/xsd-constraint, Part D, 203.7
Requirement	http://def.wmo.int/opm/2013/req/xsd-scalar-constraint/valid The content model of this element shall have a value that matches the content model of opm:ScalarConstraint.
Requirement	http://def.wmo.int/opm/2013/req/xsd-scalar-constraint/comparison-operator The XML attribute //opm:ScalarConstraint/@comparisonOperator shall specify the mathematical operator relating the scalar constraint to the supplied numeric value.
Requirement	http://def.wmo.int/opm/2013/req/xsd-scalar-constraint/comparison-operator-enumeration The value of XML attribute //opm:ScalarConstraint/@comparisonOperator shall be one of the enumeration: “ne” (not equal to), “lt” (less than), “le” (less than or equal to), “eq” (equal to), “ge” (greater than or equal to) or “gt” (greater than).
Requirement	http://def.wmo.int/opm/2013/req/xsd-scalar-constraint/unit-of-measure Unless the constraining property is dimensionless, a unit of measurement shall be indicated that is appropriate for the constraining property via XML attribute //opm:ScalarConstraint/opm:unitOfMeasure/@uom.

Note: units of measurement are specified in accordance with Part D, 1.9.

203.10 Requirements Class: Range constraint

203.10.1 This requirements class is used to describe the representation of constraints applied to an observable property according to a range of values.

Note: for example, the base property "radiance" may be constrained such that we are only concerned with radiance between wavelengths of 50nm and 100nm – "wavelength" is the constraining property and is limited to the range 50nm to 100nm.

203.10.2 XML elements describing the constraint of observable properties shall conform to all Requirements specified in Table 26.

203.10.3 XML elements describing the constraint of observable properties shall conform to all Requirements of all relevant dependencies specified in Table 26.

Table 26. Requirements class xsd-range-constraint

Requirements Class	
http://def.wmo.int/opm/2013/req/xsd-range-constraint	
Target Type	Data instance
Name	Range constraint
Dependency	http://def.wmo.int/opm/2013/req/xsd-constraint, Part D, 203.7
Requirement	http://def.wmo.int/opm/2013/req/xsd-range-constraint/valid The content model of this element shall have a value that matches the content model of opm:RangeConstraint.
Requirement	http://def.wmo.int/opm/2013/req/xsd-range-constraint/unit-of-measure Unless the constraining property is dimensionless, a unit of measurement shall be indicated that is appropriate for the constraining property via XML attribute //opm:ScalarConstraint/opm:unitOfMeasure/@uom.
Requirement	http://def.wmo.int/opm/2013/req/xsd-range-constraint/value The XML element //opm:RangeConstraint/opm:value shall contain a valid child element opm:RangeBounds wherein the start and end values of the constraining property range are defined.
Requirement	http://def.wmo.int/opm/2013/req/xsd-range-constraint/valid-range The numeric value of XML element //opm:RangeConstraint/opm:value/opm:RangeBounds/rangeStart shall be less than the numeric value of XML element //opm:RangeConstraint/opm:value/opm:RangeBounds/rangeEnd.

Requirements Class	
Requirement	http://def.wmo.int/opm/2013/req/xsd-range-constraint/start-comparison The XML attribute //opm:RangeConstraint/opm:value/opm:RangeBounds/@startComparison shall specify the mathematical operator relating the range constraint to the supplied numeric value at the lower limit of the range.
Requirement	http://def.wmo.int/opm/2013/req/xsd-range-constraint/end-comparison The XML attribute //opm:RangeConstraint/opm:value/opm:RangeBounds/@endComparison shall specify the mathematical operator relating the range constraint to the supplied numeric value at the upper limit of the range.
Requirement	http://def.wmo.int/opm/2013/req/xsd-range-constraint/comparison-operator-enumeration The value of XML attributes //opm:RangeConstraint/opm:value/opm:RangeBounds/@startComparison and //opm:RangeConstraint/opm:value/opm:RangeBounds/@endComparison shall be one of the enumeration: “ne” (not equal to), “lt” (less than), “le” (less than or equal to), “eq” (equal to), “ge” (greater than or equal to) or “gt” (greater than).

Note: units of measurement are specified in accordance with Part D, 1.9.

FM-204: SAF

FM 204-15 EXT SAF-XML SIMPLE AERONAUTICAL FEATURES

204.1 Scope

SAF-XML shall be used to represent features relating to the provision of meteorological services for aviation, such as aerodromes, runways, air traffic management units and flight information regions.

Note: the entities provided in SAF-XML are intended to describe only the level of detail required for reporting meteorological information for international civil aviation purposes. Representations providing more detailed information may be used if required.

The Requirements Classes defined in SAF-XML are listed in Table 27.

Table 27. Requirements Classes defined in SAF-XML

Requirements Classes	
Requirements Class	http://icao.int/saf/1.1/req/xsd-unique-identification, Part D, 204.3
Requirements Class	http://icao.int/saf/1.1/req/xsd-aerodrome, Part D, 204.4
Requirements Class	http://icao.int/saf/1.1/req/xsd-runway, Part D, 204.5
Requirements Class	http://icao.int/saf/1.1/req/xsd-runway-direction, Part D, 204.6
Requirements Class	http://icao.int/saf/1.1/req/xsd-aeronautical-service-provision-units, Part D, 204.7
Requirements Class	http://icao.int/saf/1.1/req/xsd-airspace-volume, Part D, 204.8
Requirements Class	http://icao.int/saf/1.1/req/xsd-airspace, Part D, 204.9

204.2 XML Schema for SAF-XML

204.2.1 Representations of information in SAF-XML shall declare XML namespaces listed in Table 28 and Table 29.

Note: additional namespace declarations may be required depending on the XML elements used within SAF-XML.

Note: the XML Schema is packaged into four XML schema documents (XSD) describing one XML namespace: http://icao.int/saf/1.1.

Note: Schematron schemas providing additional constraints are embedded within the XSD defining SAF-XML.

Table 28. XML namespaces defined for SAF-XML

XML Namespace	Default namespace prefix	Canonical location of all-components schema document
http://icao.int/saf/1.1	saf	http://schemas.wmo.int/saf/1.1/saf.xsd

Table 29. External XML namespaces used in SAF-XML

Standard	XML Namespace	Default namespace prefix	Canonical location of all-components schema document
XML Schema	http://www.w3.org/2001/XMLSchema	xs	
Schematron	http://purl.oclc.org/dsdl/schematron	sch	
XSLT v2	http://www.w3.org/1999/XSL/Transform	xsl	
XML Linking Language	http://www.w3.org/1999/xlink	xlink	
ISO 19136:2006 GML	http://www.opengis.net/gml/3.2	gml	http://schemas.opengis.net/gml/3.2.1/gml.xsd

204.3 Requirements Class: Unique identification

204.3.1 This requirements class is used to describe how the information representations of aeronautical features are identified.

Note: examples of aeronautical features include aerodromes, air traffic management units and flight information regions.

Note: to achieve consistency with the Aeronautical Information Exchange Model (AIXM 5), the method of identification defined therein is adopted here. More details may be found in the document “AIXM5 Feature Identification and Reference”.

Note: the identifier does not identify the real-world aeronautical feature itself – rather it identifies the information representation about a given aeronautical feature. The originator of information about a given aeronautical feature uniquely identifies the information record they maintain within their data management systems about a given real-world aeronautical feature. The same identifier is then re-used in downstream information systems when referring to that information record. This ensures that all parties can be confident that they are working with the same information about a given aeronautical feature. Thus if multiple systems use the same identifier for an aeronautical

feature, this indicates (i) the data is from the same source, or (ii) there are processes in place to ensure the consistency of data between those systems.

204.3.2 XML elements describing aeronautical features shall conform to all Requirements specified in Table 30.

Table 30. Requirements class xsd-unique-identification

Requirements Class	
http://icao.int/saf/1.1/req/xsd-unique-identification	
Target Type	Data instance
Name	Unique identification
Requirement	http://icao.int/saf/1.1/req/xsd-unique-identification/uniqueness An identifier scheme shall be used for assigning identity to information records that describe real-world aeronautical features which ensures that there is a reasonable confidence that a given identifier will never be unintentionally used by anyone for anything else. Different versions of the information record describing a given aeronautical feature shall be assigned different identifiers.
Requirement	http://icao.int/saf/1.1/req/xsd-unique-identification/gml-identifier The identifier for the information record describing a real-world aeronautical feature shall be specified using the XML element //gml:identifier.
Recommendation	http://icao.int/saf/1.1/req/xsd-unique-identification/uuid The identifier scheme that should be used for assigning identity to information records that describe real-world aeronautical features is UUID version 4 based on random number generation. The corresponding value of XML attribute //gml:identifier/@codeSpace associated with the use of UUID is "urn:uuid:".

Note: UUID generators are widely available; for example, please refer to the International Telecommunication Union's UUID generator, accessed at the URL http://www.itu.int/ITU-T/asn1/cgi-bin/uuid_generate. No guarantee is made regarding the availability of this UUID generation service.

204.4 Requirements Class: Aerodrome

204.4.1 This requirements class is used to describe the representation of an aerodrome. The class is targeted at providing a basic description of the aerodrome required for reporting meteorological information for international civil aviation purposes.

Note: representations providing more detailed information may be used if required.

Note: an aerodrome is a defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft/helicopters.

204.4.2 XML elements describing aerodromes shall conform to all Requirements specified in Table 31.

204.4.3 XML elements describing aerodromes shall conform to all Requirements of all relevant dependencies specified in Table 31.

Table 31. Requirements class xsd-aerodrome

Requirements Class	
http://icao.int/saf/1.1/req/xsd-aerodrome	
Target Type	Data instance
Name	Aerodrome
Dependency	http://icao.int/saf/1.1/req/xsd-unique-identification, Part D, 204.3
Requirement	http://icao.int/saf/1.1/req/xsd-aerodrome/valid The content model of this element shall have a value that matches the content model of saf:Aerodrome.
Requirement	http://icao.int/saf/1.1/req/xsd-aerodrome/icao-location-indicator If the aerodrome has a 4-letter ICAO location indicator, this shall be specified using the XML element //saf:Aerodrome/saf:locationIndicatorICAO.
Requirement	http://icao.int/saf/1.1/req/xsd-aerodrome/iata-deisgnator If the aerodrome has a 3-letter IATA designator, this shall be specified using the XML element //saf:Aerodrome/saf:designatorIATA.
Recommendation	http://icao.int/saf/1.1/req/xsd-aerodrome/designator The XML element //saf:Aerodrome/saf:designator should be used to specify the designator code for the aerodrome. If the aerodrome has a 4-letter ICAO location indicator, this should be used as the designator code. If the aerodrome does not have a 4-letter ICAO location indicator but does have a 3-letter IATA code, this should be used as the designator code. Alternatively, an artificially generated code shall be used.

Requirements Class	
Recommendation	http://icao.int/saf/1.1/req/xsd-aerodrome/name The XML element //saf:Aerodrome/saf:name should be used to specify the primary official name of the aerodrome as designated by the appropriate authority. The name should be provided in block capitals.
Recommendation	http://icao.int/saf/1.1/req/xsd-aerodrome/field-elevation The XML element //saf:Aerodrome/saf:fieldElevation should be used to specify the vertical distance above mean sea level of the highest point of the landing area.
Recommendation	http://icao.int/saf/1.1/req/xsd-aerodrome/field-elevation-unit-of-measure If specified, the vertical distance above mean sea level of the highest point of the landing area (field elevation) should be expressed in metres using the XML attribute //saf:Aerodrome/saf:fieldElevation/@uom with the value “m”.
Recommendation	http://icao.int/saf/1.1/req/xsd-aerodrome/aerodrome-reference-point The XML element //saf:Aerodrome/saf:ARP should be used to specify location of the aerodrome reference point. Coordinate reference system EPSG 4326 should be used to report the location in latitude and longitude. Coordinate reference system EPSG 4979 should be used to report the location in latitude, longitude and altitude.

Note: ICAO designators are listed in ICAO document 7910.

Note: units of measurement are specified in accordance with Part D, 1.9.

204.5 Requirements Class: Runway

204.5.1 This requirements class is used to describe the representation of a runway. The class is targeted at providing a basic description of the runway required for reporting meteorological information for international civil aviation purposes.

Note: representations providing more detailed information may be used if required.

Note: a runway is a defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft. This includes the concept of Final Approach and Take-Off Area (FATO) for helicopters.

204.5.2 XML elements describing runways shall conform to all Requirements specified in Table 32.

204.5.32 XML elements describing runway shall conform to all Requirements of all relevant dependencies specified in Table 32.

Table 32. Requirements class xsd-runway

Requirements Class	
http://icao.int/saf/1.1/req/xsd-runway	
Target Type	Data instance
Name	Runway
Dependency	http://icao.int/saf/1.1/req/xsd-unique-identification, Part D, 204.3
Dependency	http://icao.int/saf/1.1/req/xsd-aerodrome, Part D, 204.4
Requirement	http://icao.int/saf/1.1/req/xsd-runway/valid The content model of this element shall have a value that matches the content model of saf:Runway.
Recommendation	http://icao.int/saf/1.1/req/xsd-runway/associated-aerodrome The XML element //saf:Runway/saf:associatedAirportHeliport should be used to indicate the aerodrome that the runway is situated at using a value that matches the content model of saf:Aerodrome.
Recommendation	http://icao.int/saf/1.1/req/xsd-runway/designator Where an aerodrome has more than one runway, the XML element //saf:Runway/saf:designator should be used to specify the unique identifier for the runway within the aerodrome.

204.6 Requirements Class: Runway direction

204.6.1 This requirements class is used to describe the representation of one of the two landing and take-off directions of a runway.

Note: representations providing more detailed information may be used if required.

204.6.2 XML elements describing aerodromes shall conform to all Requirements specified in Table 33.

204.6.3 XML elements describing aerodromes shall conform to all Requirements of all relevant dependencies specified in Table 33.

Table 33. Requirements class xsd-runway-direction

Requirements Class	
http://icao.int/saf/1.1/req/xsd-runway-direction	
Target Type	Data instance
Name	Runway direction
Dependency	http://icao.int/saf/1.1/req/xsd-unique-identification, Part D, 204.3
Dependency	http://icao.int/saf/1.1/req/xsd-runway, Part D, 204.5
Requirement	http://icao.int/saf/1.1/req/xsd-runway-direction/valid The content model of this element shall have a value that matches the content model of saf:RunwayDirection.
Recommendation	http://icao.int/saf/1.1/req/xsd-runway-direction/used-runway The XML element //saf:RunwayDirection/saf:usedRunway should be used to indicate the associated runway using a value that matches the content model of saf:Runway.
Recommendation	http://icao.int/saf/1.1/req/xsd-runway-direction/designator The textual designator for the landing and take-off direction of the associated runway should be specified using the XML element //saf:RunwayDirection/saf:designator.
Recommendation	http://icao.int/saf/1.1/req/xsd-runway-direction/true-bearing The measured angle between true north and the landing and take-off direction should be specified using the XML element //saf:RunwayDirection/saf:trueBearing.
Recommendation	http://icao.int/saf/1.1/req/xsd-runway-direction/true-bearing-unit-of-measure The measured angle between true north and the landing and take-off direction should be expressed in degrees using the XML attribute //saf:RunwayDirection/saf:trueBearing/@uom with the value “deg”.
Recommendation	http://icao.int/saf/1.1/req/xsd-runway-direction/elevation The vertical distance above mean sea level of the highest point of the runway touchdown zone should be specified using the XML element //saf:RunwayDirection/saf:elevationTDZ.
Recommendation	http://icao.int/saf/1.1/req/xsd-runway-direction/elevation-unit-of-measure If specified, the vertical distance above mean sea level of the highest point of the runway touchdown zone should be expressed in metres using the XML attribute //saf:RunwayDirection/saf:elevationTDZ/@uom with the value “m”.

Note: examples of runway direction designators include “27”, “35L” and “01R”.

Note: the True North is the north point at which the meridian lines meet.

Note: units of measurement are specified in accordance with Part D, 1.9.

204.7 Requirements Class: Aeronautical service provision units

204.7.1 This requirements class is used to describe the representation of aeronautical service provision units.

Note: aeronautical service provision units include Aerodrome Reporting Office (ARO), Air Traffic Control Centre (ATCC), Air Traffic Services Unit (ATSU), Flight Information Centre (FIC) and Meteorological Watch Office (MWO).

Note: representations providing more detailed information may be used if required.

204.7.2 XML elements describing aeronautical service provision units shall conform to all Requirements specified in Table 34.

204.7.3 XML elements describing aeronautical service provision units shall conform to all Requirements of all relevant dependencies specified in Table 34.

Table 34. Requirements class xsd-aeronautical-service-provision-units

Requirements Class	
http://icao.int/saf/1.1/req/xsd-aeronautical-service-provision-units	
Target Type	Data instance
Name	Aeronautical service provision units
Dependency	http://icao.int/saf/1.1/req/xsd-unique-identification, Part D, 204.3
Requirement	http://icao.int/saf/1.1/req/xsd-aeronautical-service-provision-units/valid The content model of this element shall have a value that matches the content model of saf:Unit.
Requirement	http://icao.int/saf/1.1/req/xsd-aeronautical-service-provision-units/unit-type-enumeration If specified, the value of XML element //saf:Unit/saf:type shall be one of the enumeration: “ARO” (Aerodrome Reporting Office), “ATCC” (Air Traffic Control Centre), “ATSU” (Air Traffic Services Unit), “FIC” (Flight Information Centre) or “MWO” (Meteorological Watch Office).
Recommendation	http://icao.int/saf/1.1/req/xsd-aeronautical-service-provision-units/name The XML element //saf:Unit/saf:name should be used to specify the primary official name of the aeronautical service provision unit as designated by the appropriate authority. The name should be provided in block capitals.

Requirements Class	
Recommendation	http://icao.int/saf/1.1/req/xsd-aeronautical-service-provision-units/type The type of the aeronautical service provision unit should be indicated using the XML element //saf:Unit/saf:type.
Recommendation	http://icao.int/saf/1.1/req/xsd-aeronautical-service-provision-units/designator The coded designator used to identify the aeronautical service provision unit should be indicated using the XML element //saf:Unit/saf:designator.

Note: coded designators for aeronautical service provision units are specified in ICAO document 7910.

Note: the location of the aeronautical service provision unit, expressed as a reference point, may be specified using XML element //saf:Unit/saf:position.

204.8 Requirements Class: Airspace volume

204.8.1 This requirements class is used to describe the geometric representation of a three dimensional airspace volume.

Note: representations providing more detailed information may be used if required.

Note: the three dimensional region of space is specified as a two dimensional horizontal region with bounded vertical extent.

204.8.2 XML elements describing airspaces shall conform to all Requirements specified in Table 35.

Table 35. Requirements class xsd-airspace-volume

Requirements Class	
http://icao.int/saf/1.1/req/xsd-airspace-volume	
Target Type	Data instance
Name	Airspace volume
Requirement	http://icao.int/saf/1.1/req/xsd-airspace-volume/valid The content model of this element shall have a value that matches the content model of saf:AirspaceVolume.
Requirement	http://icao.int/saf/1.1/req/xsd-airspace-volume/upper-limit If the upper limit of the vertical extent of the airspace is specified (using XML element //saf:AirspaceVolume/saf:upperLimit) then the XML element //saf:AirspaceVolume/saf:upperLimitReference shall be used to specify the associated vertical reference system.

Requirements Class	
Requirement	http://icao.int/saf/1.1/req/xsd-airspace-volume/lower-limit If the lower limit of the vertical extent of the airspace is specified (using XML element //saf:AirspaceVolume/saf:lowerLimit) then the XML element //saf:AirspaceVolume/saf:lowerLimitReference shall be used to specify the associated vertical reference system.
Requirement	http://icao.int/saf/1.1/req/xsd-airspace-volume/limit-type The values of XML elements //saf:AirspaceVolume/saf:upperLimitReference and //saf:AirspaceVolume/saf:lowerLimitReference specifying a vertical reference system shall be one of the enumeration: “SFC” (distance measured from the surface of the earth), “MSL” (distance measured from mean sea level), “W84” (distance measured from the WGS84 ellipsoid) or “STD” (distance measured with an altimeter set to the standard atmosphere).
Recommendation	http://icao.int/saf/1.1/req/xsd-airspace-volume/horizontal-projection The XML element //saf:Airspace/saf:horizontalProjection should be used to describe the geometry of the horizontal extent of the airspace volume.

Note: omission of the upper limit of the vertical extent (the airspace ceiling) indicates that the airspace extends upward to, or beyond, the limit of aeronautical operations, whilst omission of the lower limit of the vertical extent (the airspace floor) indicates that the airspace extends to the land / sea surface.

Note: distance measured from mean sea level is equivalent to “altitude”.

204.9 Requirements Class: Airspace

204.9.1 This requirements class is used to describe the representation of airspaces.

Note: an airspace is a defined three dimensional region of space relevant to air traffic. Airspace types include flight information region (FIR), upper flight information region (UIR) and controlled airspace (CTA).

Note: representations providing more detailed information may be used if required.

204.9.2 XML elements describing airspaces shall conform to all Requirements specified in Table 36.

204.9.3 XML elements describing airspaces shall conform to all Requirements of all relevant Dependencies specified in Table 36.

Table 36. Requirements class xsd-airspace

Requirements Class	
http://icao.int/saf/1.1/req/xsd-airspace	
Target Type	Data instance
Name	Airspace
Dependency	http://icao.int/saf/1.1/req/xsd-unique-identification, Part D, 204.3
Dependency	http://icao.int/saf/1.1/req/xsd-airspace-volume, Part D, 204.8
Requirement	http://icao.int/saf/1.1/req/xsd-airspace/valid The content model of this element shall have a value that matches the content model of saf:Airspace.
Requirement	http://icao.int/saf/1.1/req/xsd-airspace/icao-designator-indication If the coded designator used to identify the airspace is an ICAO recognised designator then the XML element //saf:Airspace/saf:designatorICAO should have value “true”.
Requirement	http://icao.int/saf/1.1/req/xsd-airspace/airspace-type-enumeration If specified, the value of XML element //saf:Airspace/saf:type shall be one of the enumeration: “FIR” (Flight Information Region), “UIR” (Upper Flight Information Region), “FIR_UIR” (Flight Information Region or Upper Flight Information Region) or “CTA” (Controlled Airspace).
Recommendation	http://icao.int/saf/1.1/req/xsd-airspace/type The type of the airspace should be indicated using the XML element //saf:Airspace/saf:type.
Recommendation	http://icao.int/saf/1.1/req/xsd-airspace/designator The coded designator used to identify the airspace should be indicated using the XML element //saf:Airspace/saf:designator.
Recommendation	http://icao.int/saf/1.1/req/xsd-airspace/name The XML element //saf:Airspace/saf:name should be used to specify the official name of the airspace as designated by the appropriate authority. The name should be provided in block capitals.
Recommendation	http://icao.int/saf/1.1/req/xsd-airspace/geometry-component The XML element //saf:Airspace/saf:geometryComponent should be used to describe the geometric volume of the airspace using a value that matches the content model of saf:AirspaceVolume.

Note: ICAO designators are listed in ICAO document 7910.

Note: an airspace may comprise of multiple geometry elements.

FM-205: IWXXM

FM 205-15 EXT IWXXM-XML ICAO METEOROLOGICAL INFORMATION EXCHANGE MODEL

205.1 Scope

IWXXM-XML shall be used to represent observations and forecasts, and reports thereof, for international civil aviation as specified by Technical Regulations, Volume II (WMO-No. 49): Meteorological Services for International Air Navigation.

IWXXM-XML includes provision for: routine aerodrome meteorological reports (METAR), special aerodrome meteorological reports (SPECI), aerodrome forecasts (TAF) and SIGMET information.

Note: SIGMET information is information issued by a meteorological watch office concerning the occurrence or expected occurrence of specified en-route weather phenomena which may affect the safety of aircraft operations.

The Requirements Classes defined in OPM-XML are listed in Table 37.

Table 37. Requirements Classes defined in IWXXM-XML

Requirements Classes	
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-cloud-layer, Part D, 205.4
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast, Part D, 205.5
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state, Part D, 205.6
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-wind-shear, Part D, 205.7
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds, Part D, 205.8
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range, Part D, 205.9
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state, Part D, 205.10
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility, Part D, 205.11
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind, Part D, 205.12

Requirements Classes	
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record, Part D, 205.13
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation, Part D, 205.14
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast, Part D, 205.15
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record, Part D, 205.17
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast, Part D, 205.17
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report, Part D, 205.18
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-metar, Part D, 205.19
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-speci, Part D, 205.20
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-forecast, Part D, 205.21
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast, Part D, 205.22
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record, Part D, 205.23
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast, Part D, 205.24
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-taf, Part D, 205.25
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition, Part D, 205.26
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-sigmet-evolving-condition-analysis, Part D, 205.27

Requirements Classes	
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-meteorological-position, Part D, 205.28
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-meteorological-position-collection, Part D, 205.29
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-sigmet-position-analysis, Part D, 205.30
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-sigmet, Part D, 205.31
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-volcanic-ash-sigmet, Part D, 205.32
Requirements Class	http://icao.int/iwxxm/1.1/req/xsd-tropical-cyclone-sigmet, Part D, 205.33

205.2 XML Schema for IWXXM-XML

205.2.1 Representations of information in IWXXM-XML shall declare the XML namespaces listed in Table 38 and Table 39.

Note: additional namespace declarations may be required depending on the XML elements used within IWXXM-XML.

Note: the XML Schema is packaged in five XML schema documents (XSD) describing one XML namespace: http://icao.int/iwxxm/1.1.

Note: Schematron schemas providing additional constraints are embedded within the XSD defining IWXXM-XML.

Table 38. XML namespaces defined for IWXXM-XML

XML Namespace	Default namespace prefix	Canonical location of all-components schema document
http://icao.int/iwxxm/1.1	iwxxm	http://schemas.wmo.int/iwxxm/1.1/iwxxm.xsd

Table 39. External XML namespaces used in IWXXM-XML

Standard	XML Namespace	Default namespace prefix	Canonical location of all-components schema document
XML Schema	http://www.w3.org/2001/XMLSchema	xs	
Schematron	http://purl.oclc.org/dsdl/schematron	sch	
XSLT v2	http://www.w3.org/1999/XSL/Transform	xsl	
XML Linking Language	http://www.w3.org/1999/xlink	xlink	
ISO 19136:2006 GML	http://www.opengis.net/gml/3.2	gml	http://schemas.opengis.net/gml/3.2.1/gml.xsd
ISO/TS 19139:2007 metadata XML implementation	http://www.isotc211.org/2005/gmd	gmd	http://standards.iso.org/ittf/PubliclyAvailableStandards/ ISO_19139_Schemas/gmd/gmd.xsd
OGC OMXML	http://www.opengis.net/om/2.0	om	http://schemas.opengis.net/om/2.0/observation.xsd
OGC OMXML	http://www.opengis.net/sampling/2.0	sam	http://schemas.opengis.net/sampling/2.0/samplingFeature.xsd
OGC OMXML	http://www.opengis.net/samplingSpatial/2.0	sams	http://schemas.opengis.net/samplingSpatial/2.0/spatialSamplingFeature.xsd
FM 202-15 Ext METCE-XML	http://def.wmo.int/metce/2013	Metce	http://schemas.wmo.int/metce/1.1/metce.xsd
FM 203-15 Ext. OPM-XML	http://def.wmo.int/opm/2013	opm	http://schemas.wmo.int/opm/1.1/opm.xsd
FM 204-15 Ext SAF-XML	http://icao.int/saf/1.1	saf	http://schemas.wmo.int/saf/1.1/saf.xsd

205.3 Virtual typing

202.3.1 In accordance with OMXML (clause 7.2), the specialization of OM_Observation is provided through schematron restriction. The om:type element shall be used to specify the type of OM_Observation that is being encoded using the URI for the corresponding observation type listed in Part D Code Table D-4.

Note: Part D Code Table D-4 is described in Part D Appendix A.

Note: Part D Code table D-4 is published online at http://codes.wmo.int/49-2/observation-type/IWXXM/1.0.

Note: the URI for each observation type is composed by appending the *notation* to the *code-space*. As an example, the URI of MeteorologicalAerodromeForecast is http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeForecast.

Note: Each URI will resolve to provide further information about the associated observation type.

205.4 Requirements Class: Cloud layer

205.4.1 This requirements class is used to describe the representation of a cloud layer. The class is targeted at providing a basic description of the cloud layer as required for civil aviation purposes.

Note: representations providing more detailed information may be used if required.

Note: the requirements for reporting cloud information are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3 [C.3.1.] 4.5, Appendix 5 [C.3.1.] 2.2.5 and Appendix 5 [C.3.1.] 1.2.4.

205.4.2 XML elements describing cloud layers shall conform to all Requirements specified in Table 40.

Table 40. Requirements class: xsd-cloud-layer

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-cloud-layer	
Target Type	Data instance
Name	Cloud layer
Requirement	http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/valid The content model of this element shall have a value that matches the content model of iwxxm:CloudLayer.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/cloud-amount The XML element //iwxxm:CloudLayer/iwxxm:amount shall be used to report an operationally significant amount of cloud.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/cloud-amount-code If cloud amount is reported, the value of XML attribute //iwxxm:CloudLayer/iwxxm:amount/@xlink:href shall be the URI of valid term from Part D Code table D-7: Cloud amount reported at aerodrome.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/cloud-base The XML element //iwxxm:CloudLayer/iwxxm:base shall either indicate the height of the lowest level in the atmosphere that contains a perceptible quantity of cloud particles or the reason for not reporting the cloud base shall be expressed using the XML attribute //iwxxm:CloudLayer/iwxxm:base/@nilReason to indicate the appropriate nil-reason code. If a nil-reason code is provided, the XML attributes //iwxxm:CloudLayer/iwxxm:base/@xsi:nil and //iwxxm:CloudLayer/iwxxm:base/@uom shall have the values “true” and “N/A” respectively.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/cloud-base-unit-of-measure If the cloud base is reported then the vertical distance shall be expressed in metres or feet. The unit of measure shall be indicated using the XML attribute //iwxxm:CloudLayer/iwxxm:base/@uom with values “m” (metres) or “[ft_i]” (feet).
Requirement	http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/cloud-type-code If cloud type is reported, the value of XML attribute //iwxxm:CloudLayer/iwxxm:cloudType/@xlink:href shall be the URI of valid cloud type from Part D Code table D-8: Significant convective cloud type.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/cloud-type If reporting observed cloud, then the XML element //iwxxm:CloudLayer/iwxxm:cloudType should be used to report the most operationally significant type of cloud in the layer of cloud.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/nil-significant-cloud If no operationally significant cloud is reported, then the value of XML attribute //iwxxm:CloudLayer/iwxxm:amount/@nilReason should be set to http://codes.wmo.int/common/nil/nothingOfOperationalSignificance. If reporting observed cloud, then the value of XML attribute iwxxm:CloudLayer/iwxxm:cloudType/@nilReason should also be set to http://codes.wmo.int/common/nil/nothingOfOperationalSignificance.

Note: operationally significant cloud includes cloud below 1500 metres or the highest minimum sector altitude, whichever is greatest, and Cumulonimbus whenever present.

Note: Part D Code table D-1 provides a set of nil reason codes and is published at http://codes.wmo.int/common/nil.

Note: units of measurement are specified in accordance with Part D, 1.9.

Note: Part D Code table D-7 is published online at http://codes.wmo.int/49-2/CloudAmountReportedAtAerodrome.

Note: Part D Code table D-8 is published online at http://codes.wmo.int/49-2/SigConvectiveCloudType.

205.5 Requirements Class: Aerodrome cloud forecast

205.5.1 This requirements class is used to describe forecast cloud conditions at an aerodrome. The class is targeted at providing a basic description of the forecast cloud conditions as required for civil aviation purposes.

Note: representations providing more detailed information may be used if required.

Note: the requirements for reporting forecast cloud conditions are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5 [C.3.1.] 2.2.5 and Appendix 5 [C.3.1.] 1.2.4.

205.5.2 XML elements describing forecast cloud conditions shall conform to all Requirements specified in Table 41.

205.5.3 XML elements describing forecast cloud conditions shall conform to all Requirements of all relevant dependencies specified in Table 41.

Table 41. Requirements class xsd-aerodrome-cloud-forecast

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast	
Target Type	Data instance
Name	Aerodrome cloud forecast
Dependency	http://icao.int/iwxxm/1.1/req/xsd-cloud-layer, Part D, 205.4
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeCloudForecast.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast/vertical-visibility When cloud of operational significance is forecast, then the XML element //iwxxm:AerodromeCloudForecast/iwxxm:verticalVisibility shall be used to report the vertical visual range.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast/vertical-visibility-unit-of-measure If the vertical visibility is reported then the vertical distance shall be expressed in metres or feet. The unit of measure shall be indicated using the XML attribute //iwxxm:AerodromeCloudForecast/iwxxm:verticalVisibility/@uom with values “m” (metres) or “[ft_i]” (feet).

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast/cloud-layers When cloud of operational significance is forecast, then the XML element //iwxxm:AerodromeCloudForecast/iwxxm:layer, containing a valid child element //iwxxm:AerodromeCloudForecast/iwxxm:layer/iwxxm:CloudLayer, shall be used to describe the each cloud layer.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast/number-of-cloud-layers No more than four cloud layers shall be reported. If more than four significant cloud layers are forecast, then the four most significant cloud layers with respect to aviation operations shall be prioritized.

Note: operationally significant cloud includes cloud below 1500 metres or the highest minimum sector altitude, whichever is greatest, and Cumulonimbus whenever present.

Note: vertical visibility is defined as the vertical visual range into an obscuring medium.

Note: units of measurement are specified in accordance with Part D, 1.9.

205.6 Requirements Class: Aerodrome runway state

205.6.1 This requirements class is used to describe the observed runway state.

Note: representations providing more detailed information may be used if required.

Note: the requirements for reporting runway state are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3 [C.3.1.] 4.8.1.4.

205.6.2 XML elements describing forecast runway state shall conform to all Requirements specified in Table 42.

205.6.23 XML elements describing forecast runway state shall conform to all Requirements of all relevant dependencies specified in Table 42.

Table 42. Requirements class xsd-aerodrome-runway-state

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state	
Target Type	Data instance
Name	Aerodrome runway state
Dependency	http://icao.int/saf/1.1/req/xsd-runway-direction, Part D, 204.6

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeRunwayState.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/applicable-runway If XML attribute //iwxxm:AerodromeRunwayState/@allRunways is absent or has value “false”, then XML element //iwxxm:AerodromeRunwayState/iwxxm:runway, with valid child element //iwxxm:AerodromeRunwayState/iwxxm:runway/saf:RunwayDirection, shall be used to indicate the runway direction to which these conditions apply.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/all-runways If XML attribute //iwxxm:AerodromeRunwayState/@allRunways has value “true”, then XML element //iwxxm:AerodromeRunwayState/iwxxm:runway shall be absent.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/snow-closure If the aerodrome is closed due to an extreme deposit of snow, XML attribute //iwxxm:AerodromeRunwayState/@snowClosure shall have value “true”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/cleared If the runway has been cleared of meteorological deposits, then XML attribute //iwxxm:AerodromeRunwayState/@cleared shall have value “true” and XML elements //iwxxm:AerodromeRunwayState/iwxxm:depositType, //iwxxm:AerodromeRunwayState/iwxxm:contamination, //iwxxm:AerodromeRunwayState/iwxxm:depthOfDeposit and //iwxxm:AerodromeRunwayState/iwxxm:estimatedSurfaceFriction shall be absent.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/surface-friction-estimate If reported, the estimated surface friction shall be stated using the XML element //iwxxm:AerodromeRunwayState/iwxxm:estimatedSurfaceFriction and shall have numeric value greater than 0.0 and less than or equal to 0.9.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/surface-friction-estimate-unit-of-measure If reported, the estimated surface friction shall be expressed as a unitless ratio with the value of XML attribute //iwxxm:AerodromeRunwayState/iwxxm:estimatedSurfaceFriction/@uom specified as “http://www.opengis.net/def/uom/OGC/1.0/unity”.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/unreliable-surface-friction-estimate If the surface friction estimate for the runway is considered to be unreliable, then XML attribute //iwxxm:AerodromeRunwayState/@estimatedSurfaceFrictionUnreliable shall have value “true”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/unreliable-surface-friction-estimate-true If XML attribute //iwxxm:AerodromeRunwayState/@estimatedSurfaceFrictionUnreliable has value “true”, then XML element //iwxxm:AerodromeRunwayState/iwxxm:estimatedSurfaceFriction shall be absent.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/deposit-type-code If deposit type is reported, then the value of XML attribute //iwxxm:AerodromeRunwayState/iwxxm:depositType/@xlink:href shall be the URI of valid term from Part B FM 94 BUFR Code table 0 20 086: Runway deposits.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/contamination-code If runway contamination is reported, then the value of XML attribute //iwxxm:AerodromeRunwayState/iwxxm:contamination/@xlink:href shall be the URI of valid term from Part B FM 94 BUFR Code table 0 20 087: Runway contamination.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/snow-closure-affects-all-runways If XML attribute //iwxxm:AerodromeRunwayState/@snowClosure has value “true”, then XML //iwxxm:AerodromeRunwayState/@allRunways should also have value “true”; snow closure affects all runways at an aerodrome.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/deposit-depth-unit-of-measure If reported, the depth of deposit should be expressed in millimetres with the value of XML attribute //iwxxm:AerodromeRunwayState/iwxxm:depthOfDeposit/@uom specified as “mm”.

Note: For convenience, Part B FM 94 BUFR Code table 0 20 086 is published online at http://codes.wmo.int/bufr4/codeflag/0-20-086.

Note: runway contamination is expressed as a percentage the total runway area that is contaminated according to a predefined set of categories: less than 10%, between 11% and 25%, between 25% and 50% and more than 50%. These categories are listed in Part B FM 94 BUFR Code table 0 20 087: Runway contamination. For convenience, this code table is published on line at http://codes.wmo.int/bufr4/codeflag/0-20-087.

Note: units of measurement are specified in accordance with Part D, 1.9.

205.7 Requirements Class: Aerodrome wind shear

205.7.1 This requirements class is used to describe the aerodrome wind shear. The class is targeted at providing a basic description of the wind shear as required for civil aviation purposes – currently limited to indicating whether a wind shear threshold has been exceeded.

Note: the information on wind shear includes, but is not necessarily limited to, wind shear of a non-transitory nature such as might be associated with low-level temperature inversions or local topography.

Note: representations providing more detailed information may be used if required.

Note: the requirements for reporting aerodrome wind shear are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3 [C.3.1.] 4.8.1.3.

205.7.2 XML elements describing forecast runway state shall conform to all Requirements specified in Table 43.

205.7.3 XML elements describing forecast runway state shall conform to all Requirements of all relevant dependencies specified in Table 43.

Table 43. Requirements class xsd-aerodrome-wind-shear

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-aerodrome-wind-shear	
Target Type	Data instance
Name	Aerodrome wind shear
Dependency	http://icao.int/saf/1.1/req/xsd-runway-direction, Part D, 204.6
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-wind-shear/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeWindShear.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-wind-shear/applicable-runways If XML attribute //iwxxm:AerodromeWindShear/@allRunways is absent or has value “false”, then one or more XML elements //iwxxm:AerodromeWindShear/iwxxm:runway, each with valid child element //iwxxm:AerodromeWindShear/iwxxm:runway/saf:RunwayDirection, shall be used to indicate the set of runway directions to which wind shear conditions apply.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-wind-shear/all-runways If XML attribute //iwxxm:AerodromeWindShear/@allRunways has value “true”, then XML element //iwxxm:AerodromeWindShear/iwxxm:runway shall be absent.

205.8 Requirements Class: Aerodrome observed clouds

205.8.1 This requirements class is used to describe observed cloud conditions at an aerodrome. The class is targeted at providing a basic description of the observed cloud conditions as required for civil aviation purposes.

Note: representations providing more detailed information may be used if required.

Note: the requirements for reporting observed cloud conditions are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.5.

205.8.2 XML elements describing observed cloud conditions shall conform to all Requirements specified in Table 44.

205.8.2 XML elements describing observed cloud conditions shall conform to all Requirements of all relevant dependencies specified in Table 44.

Table 44. Requirements class xsd-aerodrome-observed-clouds

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds	
Target Type	Data instance
Name	Aerodrome observed clouds
Dependency	http://icao.int/iwxxm/1.1/req/xsd-cloud-layer, Part D, 205.4
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeObservedClouds.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds/amount-and-height-not-detectable-by-auto-system When an automatic observing system observes cumulonimbus clouds or towering cumulus clouds but the amount and height cannot be observed, the XML attribute //iwxxm:AerodromeObservedClouds/@amountAndHeightUnobservableByAutoSystem shall have value set to “true” and XML element //iwxxm:AerodromeObservedClouds/iwxxm:layer shall be absent.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds/either-vertical-visibility-or-cloud-layers When vertical visibility is reported, cloud layers shall not be reported. When cloud layers are reported, vertical visibility shall not be reported.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds/vertical-visibility When cloud of operational significance is observed but the amount and height cannot be observed, then the XML element //iwxxm:AerodromeObservedClouds/iwxxm:verticalVisibility shall be used to report the vertical visibility.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds/vertical-visibility-unit-of-measure If the vertical visibility is reported then the vertical distance shall be expressed in metres or feet. The unit of measure shall be indicated using the XML attribute //iwxxm:AerodromeObservedClouds/iwxxm:verticalVisibility/@uom with values “m” (metres) or “[ft_i]” (feet).
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds/cloud-layers When the amount and height of operationally significant cloud is observed, then the XML element //iwxxm:AerodromeObservedClouds/iwxxm:layer, containing a valid child element //iwxxm:AerodromeObservedClouds/iwxxm:layer/iwxxm:CloudLayer, shall be used to describe the each cloud layer.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast/number-of-cloud-layers No more than four cloud layers shall be reported. If more than four significant cloud layers are observed, then the four most significant cloud layers with respect to aviation operations shall be prioritized.

Note: operationally significant cloud includes cloud below 1500 metres or the highest minimum sector altitude, whichever is greatest, and Cumulonimbus whenever present.

Note: vertical visibility is defined as the vertical visual range into an obscuring medium.

Note: units of measurement are specified in accordance with Part D, 1.9.

205.9 Requirements Class: Aerodrome runway visual range

205.9.1 This requirements class is used to describe runway visual range for a specific runway direction at an aerodrome.

Note: the requirements for reporting runway visual range are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.3.

205.9.2 XML elements describing runway visual range shall conform to all Requirements specified in Table 45.

205.9.3 XML elements describing runway visual range shall conform to all Requirements of all relevant dependencies specified in Table 45.

Table 45. Requirements class xsd-aerodrome-runway-visual-range

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range	
Target Type	Data instance
Name	Aerodrome runway visual range
Dependency	http://icao.int/saf/1.1/req/xsd-runway-direction, Part D, 204.6
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/valid The content model of this element shall have a value that matches the content model of iwxxm:RunwayVisualRange.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/applicable-runway The XML element //iwxxm:AerodromeRunwayVisualRange/iwxxm:runway, with valid child element //iwxxm:AerodromeRunwayState/iwxxm:runway/saf:RunwayDirection, shall be used to indicate the runway direction to which these visual range conditions apply.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/mean-rvr The XML element //iwxxm:AerodromeRunwayVisualRange/iwxxm:meanRVR shall be used to express the 10-minute average for observed runway visual range or, if a marked discontinuity in visual range occurs during the 10-minute period, the average runway visual range following that marked discontinuity.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/mean-rvr-unit-of-measure The mean runway visual range shall be reported in metres. The unit of measure shall be indicated using the XML attribute //iwxxm:AerodromeRunwayVisualRange/iwxxm:meanRVR/@uom with value “m”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/mean-rvr-exceeds-2000m If the mean runway visual range exceeds 2000 metres, then the numeric value of XML element //iwxxm:AerodromeRunwayVisualRange/iwxxm:meanRVR shall be set to 2000 and the XML element //iwxxm:AerodromeRunwayVisualRange/iwxxm:meanRVROperator shall have value “ABOVE”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/mean-rvr-comparison-operator If present, the value XML element //iwxxm:AerodromeRunwayVisualRange/iwxxm:meanRVROperator shall be one of the enumeration: “ABOVE” or “BELOW”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/upward-or-downward-visual-range-tendency If the runway visual range values observed in the 10-minute period have shown a distinct tendency, such that the mean during the first 5-minutes varies by 100 metres or more when compared to the second 5-minutes, this should be indicated using the XML element //iwxxm:AerodromeRunwayVisualRange/iwxxm:pastTendency with the value “UPWARD” (visual range is increasing) or “DOWNWARD” (visual range is decreasing) as appropriate.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/no-change-in-visual-range-tendency If the runway visual range values observed in the 10-minute period have not shown a distinct tendency, this should be indicated using the XML element //iwxxm:AerodromeRunwayVisualRange/iwxxm:pastTendency with the value “NO_CHANGE”.

Note: units of measurement are specified in accordance with Part D, 1.9.

Note: the absence of XML element //iwxxm:AerodromeRunwayVisualRange/iwxxm:meanRVROperator indicates that the mean runway visual range has the numeric value reported.

Note: the absence of XML element //iwxxm:AerodromeRunwayVisualRange/iwxxm:pastTendency indicates that no distinct tendency in visual range has been observed.

205.10 Requirements Class: Aerodrome sea state

205.10.1 This requirements class is used to describe aggregated set of sea state conditions reported at an aerodrome.

Note: the requirements for reporting the sea state are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.8.1.4.

205.10.2 XML elements describing sea state shall conform to all Requirements specified in Table 46.

Table 46. Requirements class xsd-aerodrome-sea-state

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state	
Target Type	Data instance
Name	Aerodrome sea state
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeSeaState.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state/sea-surface-temperature The sea surface temperature shall be reported in Celsius (°C) using the XML element //iwxxm:AerdromeSeaState/iwxxm:seaSurfaceTemperature. The value of the associated XML attribute //iwxxm:AerdromeSeaState/iwxxm:seaSurfaceTemperature/@uom shall be “Cel”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state/either-significant-wave-height-or-sea-state When significant wave height is reported, sea state shall not be reported. When sea state is reported, significant wave height shall not be reported.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state/significant-wave-height If reported, the observed significant wave height shall be expressed using the XML element //iwxxm:AerodromeSeaState/iwxxm:significantWaveHeight.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state/sea-state-code If sea state is reported, then the value of XML attribute //iwxxm:AerodromeSeaState/iwxxm:seaState/@xlink:href shall be the URI of valid term from Part B FM 94 BUFR Code table 0 22 061: State of the sea.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state/significant-wave-height-unit-of-measure The significant wave height should be reported in metres. The unit of measure shall be indicated using the XML attribute //iwxxm:AerodromeSeaState/iwxxm:significantWaveHeight/@uom with value “m”.

Note: units of measurement are specified in accordance with Part D, 1.9.

Note: the term sea surface temperature is generally meant to be representative of the upper few metres of the ocean as opposed to the skin temperature.

Note: For convenience, Part B FM 94 BUFR Code table 0 22 061 is published online at http://codes.wmo.int/bufr4/codeflag/0-22-061.

205.11 Requirements Class: Aerodrome horizontal visibility

205.11.1 This requirements class is used to describe the horizontal visibility conditions observed at an aerodrome.

Note: the requirements for reporting the horizontal visibility are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.2.

205.11.2 XML elements describing horizontal visibility shall conform to all Requirements specified in Table 47.

Table 47. Requirements class xsd-aerodrome-horizontal-visibility

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility	
Target Type	Data instance
Name	Aerodrome horizontal visibility
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeHorizontalVisibility.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility/prevailing-visibility The prevailing visibility shall be stated using the XML element //iwxxm:AerodromeHorizontalVisibility/iwxxm:prevailingVisibility with the unit of measure metres, indicated using the XML attribute //iwxxm:AerodromeHorizontalVisibility/iwxxm:prevailingVisibility/@uom with value “m”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility/prevailing-visibility-exceeds-10000m If the prevailing visibility exceeds 10000 metres, then the numeric value of XML element //iwxxm:AerodromeHorizontalVisibility/iwxxm:prevailingVisibility shall be set to 10000 and the XML element //iwxxm:AerodromeHorizontalVisibility/iwxxm:prevailingVisibilityOperator shall have the value “ABOVE”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility/prevailing-visibility-comparison-operator If present, the value XML element //iwxxm:AerodromeHorizontalVisibility/iwxxm:prevailingVisibilityOperator shall be one of the enumeration: “ABOVE” or “BELOW”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility/minimum-visibility If reported, the minimum visibility shall be expressed using XML element //iwxxm:AerodromeHorizontalVisibility/iwxxm:minimumVisibility with the unit of measure metres, indicated using the XML attribute //iwxxm:AerodromeHorizontalVisibility/iwxxm:minimumVisibility/@uom with value “m”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility/minimum-visibility-direction If reported, the observed angle between true north and the direction of minimum visibility shall be expressed in degrees using XML element //iwxxm:AerodromeHorizontalVisibility/iwxxm:minimumVisibilityDirection, with the unit of measure indicated using the XML attribute //iwxxm:AerodromeHorizontalVisibility/iwxxm:minimumVisibilityDirection/@uom having value “deg”.

Note: units of measurement are specified in accordance with Part D, 1.9.

Note: visibility for aeronautical purposes is defined as the greater of: (i) the greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognized when observed against a bright background; or (ii) the greatest distance at which lights in the vicinity of 1000 candelas can be seen and identified against an unlit background.

Note: prevailing visibility is defined as the greatest visibility value observed which is reached within at least half the horizon circle or within at least half of the surface of the aerodrome. These areas could comprise contiguous or non-contiguous sectors.

Note: the absence of XML element //iwxxm:AerodromeHorizontalVisibility/iwxxm:prevailingVisibilityOperator indicates that the prevailing visibility has the numeric value reported.

Note: the conditions for reporting minimum visibility are that the visibility is not the same in different directions and (i) when the lowest visibility is different from the prevailing visibility and less than 1500 metres or less than 50% of the prevailing visibility and less than 5000 metres, or (ii) when the visibility is fluctuating rapidly and the prevailing visibility cannot be determined.

Note: when reporting minimum visibility, the general direction of the minimum visibility in relation to the aerodrome should be reported unless the visibility is fluctuating rapidly.

Note: the True North is the north point at which the meridian lines meet.

205.12 Requirements Class: Aerodrome surface wind

205.12.1 This requirements class is used to describe the surface wind conditions observed at an aerodrome.

Note: the requirements for reporting the surface wind conditions are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.1.

205.12.2 XML elements describing surface wind conditions shall conform to all Requirements specified in Table 48.

Table 48. Requirements class xsd-aerodrome-surface-wind

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind	
Target Type	Data instance
Name	Aerodrome surface wind
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeSurfaceWind.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind/mean-wind-speed The mean wind speed shall be stated using the XML element //iwxxm:AerodromeSurfaceWind/iwxxm:meanWindSpeed with the unit of measure metres per second, knots or kilometres per hour. The unit of measure is indicated using the XML attribute //iwxxm:AerodromeSurfaceWind/iwxxm:meanWindSpeed/@uom with value “m/s” (metres per second), “[kn_i]” (knots) or “km/h” (kilometres per hour).

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind/variable-wind-direction If the wind direction is variable, then the XML attribute //iwxxm:AerodromeSurfaceWind/@variableDirection shall have the value “true” and XML element //iwxxm:AerodromeSurfaceWind/iwxxm:meanWindDirection shall be absent.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind/steady-wind-direction If the wind direction is not variable, then (i) the observed angle between true north and the mean direction from which the wind is blowing shall be expressed using XML element //iwxxm:AerodromeSurfaceWind/iwxxm:meanWindDirection, with the unit of measure indicated using the XML attribute //iwxxm:AerodromeSurfaceWind/iwxxm:meanWindDirection/@uom having value “deg”; (ii) the XML attribute //iwxxm:AerodromeSurfaceWind/@variableDirection shall be absent or have the value “false”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind/extreme-wind-direction If the extremes of wind direction variability are reported, then (i) the observed angle between true north and extreme clockwise direction from which the wind is blowing shall be expressed using XML element //iwxxm:AerodromeSurfaceWind/iwxxm:extremeClockWiseWindDirection; (ii) the observed angle between true north and extreme counter-clockwise direction from which the wind is blowing shall be expressed using XML element //iwxxm:AerodromeSurfaceWind/iwxxm:extremeCounterClockWiseWindDirection; (iii) the unit of measure for each extreme wind direction shall indicated using the XML attribute @uom with value “deg”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind/gust-speed If reported, the observed gust speed should be stated using the XML element //iwxxm:AerodromeSurfaceWind/iwxxm:windGustSpeed and expressed in metres per second, knots or kilometres per hour. The unit of measure shall be indicated using the XML attribute //iwxxm:AerodromeSurfaceWind/iwxxm:windGustSpeed/@uom with value “m/s” (metres per second), “[kn_i]” (knots) or “km/h” (kilometres per hour).

Note: the mean wind speed is the average wind speed observed over the previous ten minutes.

Note: the gust speed is the maximum wind speed observed over the previous ten minutes.

Note: wind direction is reported as variable (VRB) if, during the ten minute observation of mean wind speed, the variation of wind direction is (i) 180 degrees or more, or (ii) 60 degrees or more when the wind speed is less than 1.5 metres per second (3 knots).

Note: extreme directional variations of wind are reported if, during the ten minute observation of mean wind speed, the variation of wind direction is 60 degrees or more and less than 180 degrees and the wind speed is 1.5 metres per second (3 knots) or more.

Note: the absence of XML attribute //iwxxm:AerodromeSurfaceWind/@variableDirection implies a "false" value; e.g. the wind direction is not variable.

Note: units of measurement are specified in accordance with Part D, 1.9.

Note: the True North is the north point at which the meridian lines meet.

205.13 Requirements Class: Meteorological aerodrome observation record

205.13.1 This requirements class is used to describe the aggregated set of meteorological conditions observed at an aerodrome.

205.13.2 XML elements describing the set of meteorological conditions observed at an aerodrome shall conform to all Requirements specified in Table 49.

205.13.3 XML elements describing the set of meteorological conditions observed at an aerodrome shall conform to all Requirements of all relevant dependencies specified in Table 49.

Table 49. Requirements class xsd-meteorological-aerodrome-observation-record

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record	
Target Type	Data instance
Name	Meteorological aerodrome observation record
Dependency	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state, Part D, 205.6
Dependency	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-wind-shear, Part D, 205.7
Dependency	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds, Part D, 205.8
Dependency	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range, Part D, 205.9
Dependency	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state, Part D, 205.10

Requirements Class	
Dependency	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility, Part D, 205.11
Dependency	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind, Part D, 205.12
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/valid The content model of this element shall have a value that matches the content model of iwxxm:MeteorologicalAerodromeObservationRecord.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/cavok If the conditions associated with CAVOK are observed, then (i) the XML attribute //iwxxm:MeteorologicalAerodromeObservationRecord/@cloudAndVisibilityOK shall have value “true”; and (ii) the following XML elements shall be absent: //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:visibility, //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:rvr, //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:presentWeather and //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:cloud.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/air-temperature The air temperature observed at the aerodrome shall be reported in Celsius (°C) using the XML element //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:airTemperature. The value of the associated XML attribute @uom shall be “Cel”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/dew-point-temperature The dew-point temperature observed at the aerodrome shall be reported in Celsius (°C) using the XML element //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:dewpointTemperature. The value of the associated XML attribute @uom shall be “Cel”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/qnh The atmospheric pressure, QNH, observed at the aerodrome shall be reported in hectopascals (hPa) using the XML element //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:qnh. The value of the associated XML attribute @uom shall be “hPa”.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/present-weather If present weather is reported, the value of XML attribute //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:presentWeather/@xlink:href shall be the URI of a valid weather phenomenon code from Part D Code table D-6: Aerodrome present or forecast weather.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/number-of-present-weather-codes No more than three present weather codes shall be reported.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/recent-weather If recent weather is reported, the value of XML attribute //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:recentWeather/@xlink:href shall be the URI of a valid weather phenomenon code from Part D Code table D-5: Aerodrome recent weather.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/number-of-recent-weather-codes No more than three recent weather codes shall be reported.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/surface-wind Surface wind conditions observed at the aerodrome shall be reported using the XML element //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:surfaceWind containing a valid child element iwxxm:AerodromeSurfaceWind.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/runway-state If reported, the surface conditions for a given runway direction shall be expressed using the XML element //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:runwayState containing a valid child element iwxxm:AerodromeRunwayState.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/wind-shear If reported, the wind shear conditions for the aerodrome shall be expressed using the XML element //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:windShear containing a valid child element iwxxm:AerodromeWindShear.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/cloud If reported, the cloud conditions observed at the aerodrome shall be expressed using the XML element //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:cloud containing a valid child element iwxxm:AerodromeObservedClouds.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/runway-visual-range If reported, the visual range conditions for a given runway direction shall be expressed using the XML element //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:rvr containing a valid child element iwxxm:AerodromeRunwayVisualRange.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/number-of-rvr-groups Visual range conditions shall be reported for no more than four runway directions.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/sea-state If reported, the sea state conditions observed at the aerodrome shall be expressed using the XML element //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:seaState containing a valid child element iwxxm:AerodromeSeaState.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/visibility If reported, the horizontal visibility conditions observed at the aerodrome shall be expressed using the XML element //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:visibility containing a valid child element iwxxm:AerodromeHorizontalVisibility.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/present-weather-not-observable If present weather is not observable due to sensor failure or obstruction the value of XML attribute //iwxxm:MeteorologicalAerodromeObservationRecord/iwxxm:presentWeather/@nilReason should indicate the URI “http://codes.wmo.int/common/nil/notObservable”

Note: units of measurement are specified in accordance with Part D, 1.9.

Note: cloud and visibility information is omitted when considered to be insignificant to aeronautical operations at an aerodrome. This occurs when: (i) visibility exceeds 10 kilometres, (ii) no cloud is present below 1500 metres or the minimum sector altitude, whichever is greatest, and there is no

cumulonimbus at any height, and (iii) there is no weather of operational significance. These conditions are referred to as “CAVOK”. Use of CAVOK is specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 2.2.

Note: the requirements for reporting air temperature and dew-point temperature are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.6.

Note: the requirements for reporting atmospheric pressure (QNH) are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.7.

Note: the requirements for reporting present weather are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.4.

Note: Part D Code table D-6 is published online at http://codes.wmo.int/49-2/AerodromePresentOrForecastWeather.

Note: the requirements for reporting recent weather are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.8.1.1.

Note: Part D Code table D-5 is published online at http://codes.wmo.int/49-2/AerodromeRecentWeather.

Note: the requirements for reporting the surface wind conditions are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.1.

Note: the requirements for reporting runway state are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3 [C.3.1.] 4.8.1.4.

Note: the requirements for reporting aerodrome wind shear are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3 [C.3.1.] 4.8.1.3.

Note: the requirements for reporting observed cloud conditions are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.5.

Note: information on runway visual range shall be omitted if the prevailing visibility exceeds 1500 metres. Details of the requirements for reporting runway visual range are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.3.

Note: the requirements for reporting the sea state are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.8.1.4.

Note: the requirements for reporting the horizontal visibility are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.2.

205.14 Requirements Class: Meteorological aerodrome observation

205.14.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the ‘result’ of the observation describes the aggregated set of meteorological conditions observed at an aerodrome, the ‘feature of interest’ is a representative point location within the aerodrome at which the meteorological conditions were observed and the ‘procedure’ provides the set of information as specified by WMO.

Note: MeteorologicalAerodromeObservation is a subclass of ComplexSamplingMeasurement defined within METCE.

205.14.2 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeObservation shall conform to all Requirements in Table 50.

205.14.3 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeObservation shall conform to all Requirements of all relevant dependencies in Table 50 with the exception of those requirements listed as superseded in Part D, 205.14.4.

205.14.4 The requirements and dependencies inherited from Requirements class http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement (as specified in Part D, 202.4) listed in Table 51 are superseded by requirements defined herein and shall no longer apply.

Note: XML implementation of iwxxm:MeteorologicalAerodromeObservation is dependent on:

OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation]

Table 50. Requirements class xsd-meteorological-aerodrome-observation

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation	
Target Type	Data instance
Name	Meteorological aerodrome observation
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation, OMXML clause 7.3
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/sampling, OMXML clause 7.14
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling, OMXML clause 7.15
Dependency	http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement, Part D, 202.4
Dependency	http://icao.int/saf/1.1/req/xsd-aerodrome, Part D, 204.4
Dependency	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record, Part D, 205.13

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation/feature-of-interest The XML element //om:OM_Observation/om:featureOfInterest shall contain a valid child element sams:SF_SpatialSamplingFeature that describes the reference point to which the observed meteorological conditions apply. The XML element //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:type shall have value "http://www.opengis.net/def/samplingFeatureType/OGC-OM/2.0/SF_SamplingPoint".
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation/sampled-feature The XML element //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature shall contain a valid child element saf:Aerodrome that describes the aerodrome to which the observed meteorological conditions apply.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation/result If reported, the XML element //om:OM_Observation/om:result shall contain a valid child element iwxxm:MeteorologicalAerodromeObservationRecord that describes the aggregated set of meteorological conditions observed at the target aerodrome.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation/phenomenon-time The XML element //om:OM_Observation/om:phenomenonTime shall contain a valid child element gml:TimeInstant that describes the time at which the observation occurred.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation/result-time The XML element //om:OM_Observation/om:resultTime shall contain a valid child element gml:TimeInstant that describes the time at which the observation was made available for dissemination.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation/observed-property The XML attribute //om:OM_Observation/om:observedProperty/@xlink:href should have value "http://codes.wmo.int/49-2/observable-property/MeteorologicalAerodromeObservation".
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation/procedure The value of XML element //om:OM_Observation/om:procedure/metce:Process/gml:description should be used to cite the Technical Regulations relating to meteorological aerodrome observations.

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/observation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/observation (OMXML clause A.1).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/sampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/sampling (OMXML clause A.12).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/spatialSampling (OMXML clause A.13).

Note: URI http://codes.wmo.int/49-2/observable-property/MeteorologicalAerodromeObservation refers to an XML document that defines the aggregate set of observable properties relevant to a meteorological aerodrome observation.

Note: the Technical Regulations relating to meteorological observations may be cited as: "Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3: Technical specifications related to meteorological observations and reports".

Note: the time at which the observation is made available for dissemination may be a few minutes after the observation occurred.

Note: in the case of NIL report (e.g. to indicate that an anticipated meteorological aerodrome observation report is considered to be "MISSING"), no meteorological conditions are provided. In these cases, the XML element //om:OM_Observation/om:result has no child elements and the XML attribute //om:OM_Observation/om:result/@nilReason is used to indicate why the "result" is absent.

Table 51. Superseded requirements and dependencies from xsd-complex-sampling-measurement

Superseded requirements and dependencies	
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/complexObservation, OMXML clause 7.10
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components, SWE Common 2.0 clause 8.1
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-record-components, SWE Common 2.0 clause 8.2
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-encodings, SWE Common 2.0 clause 8.5
Dependency	http://www.opengis.net/spec/SWE/2.0/req/general-encoding-rules, SWE Common 2.0 clause 9.1
Dependency	http://www.opengis.net/spec/SWE/2.0/req/text-encoding-rules, SWE Common 2.0 clause 9.2
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xml-encoding-rules, SWE Common 2.0 clause 9.3
Requirement	http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement/xmlns-declaration-swe, Part D, 202.4

205.15 Requirements Class: Aerodrome surface wind trend forecast

205.15.1 This requirements class is used to describe the surface wind conditions forecast at an aerodrome as appropriate for inclusion in a trend forecast of a routine or special meteorological aerodrome report.

Note: the requirements for reporting the surface wind conditions within a trend forecast are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 2.2.2.

205.15.2 XML elements describing surface wind conditions shall conform to all Requirements specified in Table 52.

Table 52. Requirements class xsd-aerodrome-surface-wind-trend-forecast

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast	
Target Type	Data instance
Name	Aerodrome surface wind trend forecast
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeSurfaceWindTrendForecast.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast/mean-wind-speed The forecast mean wind speed shall be stated using the XML element //iwxxm:AerodromeSurfaceWindTrendForecast/iwxxm:meanWindSpeed with the unit of measure metres per second, knots or kilometres per hour. The unit of measure is indicated using the XML attribute @uom with value “m/s” (metres per second), “[kn_i]” (knots) or “km/h” (kilometres per hour)
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast/wind-direction If the forecast mean wind direction is reported, then angle between true north and the mean direction from which the wind is forecast to be blowing shall be expressed using XML element //iwxxm:AerodromeSurfaceWindTrendForecast/iwxxm:meanWindDirection, with the unit of measure indicated using the XML attribute @uom having value “deg”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast/gust-speed If reported, the forecast gust speed should be stated using the XML element //iwxxm:AerodromeSurfaceWindTrendForecast/iwxxm:windGustSpeed and expressed in metres per second, knots or kilometres per hour. The unit of measure shall be indicated using the XML attribute //iwxxm:AerodromeSurfaceWind/iwxxm:windGustSpeed/@uom with value “m/s” (metres per second), “[kn_i]” (knots) or “km/h” (kilometres per hour).

Note: units of measurement are specified in accordance with Part D, 1.9.

Note: the True North is the north point at which the meridian lines meet.

205.16 Requirements Class: Meteorological aerodrome trend forecast record

205.16.1 This requirements class is used to describe the aggregated set of meteorological conditions forecast at an aerodrome as appropriate for inclusion in a trend forecast of a routine or special meteorological aerodrome report.

205.16.2 XML elements describing the set of meteorological conditions for inclusion in a trend forecast shall conform to all Requirements specified in Table 53.

205.16.3 XML elements describing the set of meteorological conditions for inclusion in a trend forecast shall conform to all Requirements of all relevant dependencies specified in Table 53.

Table 53. Requirements class xsd-meteorological-aerodrome-trend-forecast-record

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record	
Target Type	Data instance
Name	Meteorological aerodrome trend forecast record
Dependency	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast, Part D, 205.5
Dependency	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast, Part D, 205.15
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/valid The content model of this element shall have a value that matches the content model of iwxxm:MeteorologicalAerodromeTrendForecastRecord.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/change-indicator-nosig If no operationally significant changes to the meteorological conditions are forecast for the aerodrome, then the XML attribute //iwxxm:MeteorologicalAerodromeTrendForecastRecord/@changeIndicator shall have the value “NO_SIGNIFICANT_CHANGES”.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/change-indicator-becmg If the meteorological conditions forecast for the aerodrome are expected to reach or pass through specified values at a regular or irregular rate, then the XML attribute //iwxxm:MeteorologicalAerodromeTrendForecastRecord/@changeIndicator shall have the value “BECOMING”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/change-indicator-tempo If temporary fluctuations in the meteorological conditions forecast for the aerodrome are expected occur, then the XML attribute //iwxxm:MeteorologicalAerodromeTrendForecastRecord/@changeIndicator shall have the value “TEMPORARY_FLUCTUATIONS”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/cavok If the conditions associated with CAVOK are forecast, then (i) the XML attribute //iwxxm:MeteorologicalAerodromeTrendForecastRecord/@cloudAndVisibilityOK shall have value “true”; and (ii) the following XML elements shall be absent: //iwxxm:MeteorologicalAerodromeTrendForecastRecord/iwxxm:prevailingVisibility, //iwxxm:MeteorologicalAerodromeTrendForecastRecord/iwxxm:prevailingVisibilityOperator, //iwxxm:MeteorologicalAerodromeTrendForecastRecord/iwxxm:forecastWeather and //iwxxm:MeteorologicalAerodromeTrendForecastRecord/iwxxm:cloud.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/prevailing-visiblity If reported, the prevailing visibility shall be stated using the XML element //iwxxm:MeteorologicalAerodromeTrendForecastRecord/iwxxm:prevailingVisibility with the unit of measure metres, indicated using the XML attribute //iwxxm:MeteorologicalAerodromeTrendForecastRecord/iwxxm:prevailingVisibility/@uom with value “m”.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/prevailing-visibility-exceeds-10000m If the prevailing visibility exceeds 10000 metres, then the numeric value of XML element //iwxxm:MeteorologicalAerodromeTrendForecastRecord/iwxxm:prevailingVisibility shall be set to 10000 and the XML element //iwxxm:MeteorologicalAerodromeTrendForecastRecord/iwxxm:prevailingVisibilityOperator shall have the value “ABOVE”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/prevailing-visibility-comparison-operator If present, the value XML element //iwxxm:MeteorologicalAerodromeTrendForecastRecord/iwxxm:prevailingVisibilityOperator shall be one of the enumeration: “ABOVE” or “BELOW”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/forecast-weather If forecast weather is reported, the value of XML attribute //iwxxm:MeteorologicalAerodromeTrendForecastRecord/iwxxm:forecastWeather/@xlink:href shall be the URI of a valid weather phenomenon code from Part D Code table D-6: Aerodrome present or forecast weather.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/number-of-forecast-weather-codes No more than three forecast weather codes shall be reported.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/surface-wind Surface wind conditions forecast for the aerodrome shall be reported using the XML element //iwxxm:MeteorologicalAerodromeTrendForecastRecord/iwxxm:surfaceWind containing a valid child element iwxxm:AerodromeSurfaceWindTrendForecast.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/cloud If reported, the cloud conditions forecast for the aerodrome shall be expressed using the XML element //iwxxm:MeteorologicalAerodromeTrendForecastRecord/iwxxm:cloud containing a valid child element iwxxm:AerodromeCloudForecast.

Note: units of measurement are specified in accordance with Part D, 1.9.

Note: temporary fluctuations in the meteorological conditions occur when those condition reach or pass specified values and last for a period of time less than one hour in each instance and, in the

aggregate, cover less than one-half the period during which the fluctuations are forecast to occur (Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 2.3.3).

Note: the use of change indicators is specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 2.3 and Appendix 3, [C.3.1.] Table A3-3

Note: cloud and visibility information is omitted when considered to be insignificant to aeronautical operations at an aerodrome. This occurs when: (i) visibility exceeds 10 kilometres, (ii) no cloud is present below 1500 metres or the minimum sector altitude, whichever is greatest, and there is no cumulonimbus at any height, and (iii) there is no weather of operational significance. These conditions are referred to as “CAVOK”. Use of CAVOK is specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 2.2.

Note: visibility for aeronautical purposes is defined as the greater of: (i) the greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognized when observed against a bright background; or (ii) the greatest distance at which lights in the vicinity of 1000 candelas can be seen and identified against an unlit background.

Note: prevailing visibility is defined as the greatest visibility value observed which is reached within at least half the horizon circle or within at least half of the surface of the aerodrome. These areas could comprise contiguous or non-contiguous sectors.

Note: the requirements for reporting prevailing visibility conditions within a trend forecast are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 2.2.3.

Note: the absence of XML element //iwxxm:MeteorologicalAerodromeTrendForecastRecord/iwxxm:prevailingVisibilityOperator indicates that the prevailing visibility has the numeric value reported.

Note: the requirements for reporting forecast weather within a trend forecast are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 2.2.4.

Note: Part D Code table D-6 is published online at http://codes.wmo.int/49-2/AerodromePresentOrForecastWeather.

Note: the requirements for reporting the surface wind conditions within a trend forecast are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 2.2.2.

Note: the requirements for reporting cloud conditions within a trend forecast are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 2.2.5.

205.17 Requirements Class: Meteorological aerodrome trend forecast

205.17.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the ‘result’ of the observation describes the aggregated set of meteorological conditions forecast at an aerodrome as appropriate for inclusion in a trend forecast, the ‘feature of interest’ is a representative point location within the aerodrome for which the meteorological conditions were forecast and the ‘procedure’ provides the set of information as specified by WMO.

Note: MeteorologicalAerodromeTrendForecast is a subclass of ComplexSamplingMeasurement defined within METCE.

205.17.2 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeTrendForecast shall conform to all Requirements in Table 54.

205.17.3 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeTrendForecast shall conform to all Requirements of all relevant dependencies in Table 54 with the exception of those requirements listed as superseded in Part D, 205.17.4.

205.17.4 The requirements and dependencies inherited from Requirements class http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement (as specified in Part D, 202.4) listed in Table 55 are superseded by requirements defined herein and shall no longer apply.

Note: XML implementation of iwxxm:MeteorologicalAerodromeTrendForecast is dependent on:

OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation]

Table 54. Requirements class xsd-meteorological-aerodrome-trend-forecast

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast	
Target Type	Data instance
Name	Meteorological aerodrome trend forecast
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation, OMXML clause 7.3
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/sampling, OMXML clause 7.14
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling, OMXML clause 7.15
Dependency	http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement, Part D, 202.4
Dependency	http://icao.int/saf/1.1/req/xsd-aerodrome, Part D, 204.4
Dependency	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record, Part D, 205.16
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-trend-forecast/feature-of-interest The XML element //om:OM_Observation/om:featureOfInterest shall contain a valid child element sams:SF_SpatialSamplingFeature that describes the reference point to which the forecast meteorological conditions apply. The XML element //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:type shall have value "http://www.opengis.net/def/samplingFeatureType/OGC-OM/2.0/SF_SamplingPoint".

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast/sampled-feature The XML element //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature shall contain a valid child element saf:Aerodrome that describes the aerodrome to which the forecast meteorological conditions apply.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast/result The XML element //om:OM_Observation/om:result shall contain a valid child element iwxxm:MeteorologicalAerodromeTrendForecastRecord that describes the aggregated set of meteorological conditions forecast for the target aerodrome.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast/phenomenon-time The XML element //om:OM_Observation/om:phenomenonTime shall contain a valid child element gml:TimeInstant or gml:TimePeriod that describes the time for which the forecast is valid.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast/result-time The XML element //om:OM_Observation/om:resultTime shall contain a valid child element gml:TimeInstant that describes the time at which the trend forecast was made available for dissemination.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast/observed-property The XML attribute //om:OM_Observation/om:observedProperty/@xlink:href should have value “http://codes.wmo.int/49-2/observable-property/MeteorologicalAerodromeTrendForecast”.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast/procedure The value of XML element //om:OM_Observation/om:procedure/metce:Process/gml:description should be used to cite the Technical Regulations relating to trend forecasts for aerodromes.

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/observation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/observation (OMXML clause A.1).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/sampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/sampling (OMXML clause A.12).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/spatialSampling (OMXML clause A.13).

Note: URI http://codes.wmo.int/49-2/observable-property/MeteorologicalAerodromeTrendForecast refers to an XML document that defines the aggregate set of observable properties relevant to a trend forecast.

Note: the Technical Regulations relating to trend forecasts may be cited as: "Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 2: Criteria related to trend forecasts".

Note: a forecast may be provided for a specific time instant or a time period. Requirements regarding the specification of time for which the forecast is valid are specified at Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 2.3.

Table 55. Superseded requirements and dependencies from xsd-complex-sampling-measurement

Superseded requirements and dependencies	
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/complexObservation, OMXML clause 7.10
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components, SWE Common 2.0 clause 8.1
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-record-components, SWE Common 2.0 clause 8.2
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-encodings, SWE Common 2.0 clause 8.5
Dependency	http://www.opengis.net/spec/SWE/2.0/req/general-encoding-rules, SWE Common 2.0 clause 9.1
Dependency	http://www.opengis.net/spec/SWE/2.0/req/text-encoding-rules, SWE Common 2.0 clause 9.2
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xml-encoding-rules, SWE Common 2.0 clause 9.3
Requirement	http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement/xmlns-declaration-swe, Part D, 202.4

205.18 Requirements Class: Meteorological aerodrome observation report

205.18.1 This requirements class is used to describe the report within which meteorological aerodrome observations, and optionally one or more trend forecasts, are provided.

Note: the reporting requirements for routine and special meteorological aerodrome reports are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3 and Appendix 5, [C.3.1] 2.

205.18.2 XML elements describing routine or special meteorological aerodrome reports shall conform to all Requirements specified in Table 56.

205.18.3 XML elements describing routine or special meteorological aerodrome reports shall conform to all Requirements of all relevant dependencies specified in Table 56.

Table 56. Requirements class xsd-meteorological-aerodrome-observation-report

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report	
Target Type	Data instance
Name	Meteorological aerodrome observation report
Dependency	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation, Part D, 205.14
Dependency	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast, Part D, 205.17
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/valid The content model of this element shall have a value that matches the content model of iwxxm:MeteorologicalAerodromeObservationReport.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/status The status of the report shall be indicated using the XML attribute @status with the value being one of the enumeration: “NORMAL”, “MISSING” or “CORRECTION”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/automated-station If the meteorological aerodrome observation included within the report has been generated by an automated system, the value of XML attribute @automatedStation shall be set to “true”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/observation The XML element iwxxm:observation shall contain a valid child element om:OM_Observation of type MeteorologicalAerodromeObservation. The value of the XML attribute iwxxm:observation/om:OM_Observation/om:type/@xlink:href shall be the URI “http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeObservation”.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/trend-forecast If trend forecasts are reported, the value of XML element iwxxm:trendForecast shall be a valid child element om:OM_Observation of type MeteorologicalAerodromeTrendForecast. For each trend forecast, the value of the XML attribute iwxxm:trendForecast/om:OM_Observation/om:type/@xlink:href shall be the URI "http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeTrendForecast".
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/number-of-trend-forecasts No more than three trend forecasts shall be reported.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/unique-subject-aerodrome The observation and, if reported, trend forecasts shall refer to the same aerodrome. All values of XML element //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature/saf:Aerodrome/gml:identifier within the meteorological aerodrome observation report shall be identical.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/nil-report If XML attribute has value @status has value "MISSING", then a NIL report shall be provided: i) XML element iwxxm:observation/om:OM_Observation/om:result shall have no child elements and XML attribute iwxxm:observation/om:OM_Observation/om:result/@nilReason shall provide an appropriate nil-reason. ii) XML attribute @automatedStation shall be absent; and iii) XML element iwxxm:trendForecast shall be absent.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/nosig If no change of operational significance is forecast, then a single XML element iwxxm:trendForecast should be included with no child elements therein and the value XML attribute iwxxm:trendForecast/@nilReason should indicate "inapplicable".

Note: a report with status "CORRECTED" indicates that content has been amended to correct an error identified in an earlier report. The XML element //om:OM_Observation/om:resultTime/gml:TimeInstant is used to reflect the dissemination time of the corrected report.

Note: a report with status "MISSING" indicates that a routine report has not been provided on the anticipated timescales. Such a report does not contain details of any observed or forecast meteorological conditions and is often referred to as a "NIL" report.

Note: the requirements relating to reporting the use of an automated system are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.9.

Note: if XML attribute @automatedStation is absent then the value “false” is inferred; e.g. the meteorological aerodrome observation included within the report has not been generated by an automated system.

Note: within an XML encoded meteorological aerodrome report it is likely that only one instance of saf:Aerodrome will physically be present; subsequent assertions about the aerodrome may use xlinks to refer to the previously defined saf:Aerodrome element in order to keep the XML document size small. As such, validation of requirement http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/unique-subject-aerodrome is applied once any xlinks, if used, have been resolved.

Note: Part D Code table D-1 provides a set of nil reason codes and is published at http://codes.wmo.int/common/nil.

205.19 Requirements Class: METAR

205.19.1 This requirements class is used to describe the routine meteorological aerodrome reports (METAR).

205.19.2 XML elements describing METARs shall conform to all Requirements specified in Table 57.

205.19.2 XML elements describing METARs shall conform to all Requirements of all relevant dependencies specified in Table 57.

Table 57. Requirements class xsd-metar

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-metar	
Target Type	Data instance
Name	METAR
Dependency	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report, Part D, 205.18
Requirement	http://icao.int/iwxxm/1.1/req/xsd-metar/valid The content model of this element shall have a value that matches the content model of iwxxm:METAR.

205.20 Requirements Class: SPECI

205.20.1 This requirements class is used to describe the special meteorological aerodrome reports (SPECI).

205.20.2 XML elements describing SPECIs shall conform to all Requirements specified in Table 58.

205.20.3 XML elements describing SPECIs shall conform to all Requirements of all relevant dependencies specified in Table 58.

Table 58. Requirements class xsd-speci

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-speci	
	Data instance
Name	SPECI
Dependency	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report, Part D, 205.18
Requirement	http://icao.int/iwxxm/1.1/req/xsd-speci/valid The content model of this element shall have a value that matches the content model of iwxxm:SPECI.

205.21 Requirements Class: Aerodrome surface wind forecast

205.21.1 This requirements class is used to describe the surface wind conditions forecast at an aerodrome as appropriate for inclusion in an aerodrome forecast report (TAF).

Note: the requirements for reporting the surface wind conditions within a TAF specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1.2.1.

205.21.2 XML elements describing surface wind conditions shall conform to all Requirements specified in Table 59.

205.21.2 XML elements describing surface wind conditions shall conform to all Requirements of all dependencies specified in Table 59.

Table 59. Requirements class xsd-aerodrome-surface-wind-forecast

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-forecast	
Target Type	Data instance
Name	Aerodrome surface wind forecast

Requirements Class	
Dependency	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast, Part D, 205.12
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-forecast/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeSurfaceWindForecast.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-forecast/variable-wind-direction If the wind direction is variable, then the XML attribute //iwxxm:AerodromeSurfaceWindForecast/@variableWindDirection shall have the value “true” and XML element //iwxxm:AerodromeSurfaceWindForecast/iwxxm:meanWindDirection shall be absent.

Note: wind direction is reported as variable (VRB) if is not possible to forecast a prevailing surface wind direction due to expected variability, for example, during light wind conditions (less than 3 knots) or thunderstorms.

205.22 Requirements Class: Aerodrome air temperature forecast

205.22.1 This requirements class is used to describe the temperature conditions forecast at an aerodrome as appropriate for inclusion in an aerodrome forecast report (TAF), including the maximum and minimum temperature values and their time of occurrence.

Note: the requirements for reporting the surface wind conditions within a TAF specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1.2.5.

205.22.2 XML elements describing temperature conditions shall conform to all Requirements specified in Table 60.

Table 60. Requirements class xsd-aerodrome-air-temperature-forecast

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast	
Target Type	Data instance
Name	Aerodrome air temperature forecast
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeAirTemperatureForecast.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast/maximum-temperature The maximum air temperature anticipated during the forecast period shall be reported in Celsius (°C) using the XML element //iwxxm:AerodromeAirTemperatureForecast/iwxxm:maximumAirTemperature. The value of the associated XML attribute @uom shall be “Cel”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast/maximum-temperature-time The XML element //iwxxm:AerodromeAirTemperatureForecast/iwxxm:maximumAirTemperatureTime shall have a valid child element gml:TimeInstant that describes the time at which the maximum air temperature is anticipated to occur.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast/minimum-temperature The minimum air temperature anticipated during the forecast period shall be reported in Celsius (°C) using the XML element //iwxxm:AerodromeAirTemperatureForecast/iwxxm:minimumAirTemperature. The value of the associated XML attribute @uom shall be “Cel”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast/minimum-temperature-time The XML element //iwxxm:AerodromeAirTemperatureForecast/iwxxm:minimumAirTemperatureTime shall have a valid child element gml:TimeInstant that describes the time at which the minimum air temperature is anticipated to occur.

Note: units of measurement are specified in accordance with Part D, 1.9.

205.23 Requirements Class: Meteorological aerodrome forecast record

205.23.1 This requirements class is used to describe the aggregated set of meteorological conditions forecast at an aerodrome as appropriate for inclusion in a aerodrome forecast report (TAF).

205.23.2 XML elements describing the set of meteorological conditions for inclusion in an aerodrome forecast shall conform to all Requirements specified in Table 61.

205.23.3 XML elements describing the set of meteorological conditions for inclusion in an aerodrome forecast shall conform to all Requirements of all relevant dependencies specified in Table 61.

Table 61. Requirements class xsd-meterological-aerodrome-forecast-record

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record	
Target Type	Data instance
Name	Meteorological aerodrome forecast record
Dependency	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast, Part D, 205.5
Dependency	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-forecast, Part D, 205.21
Dependency	http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast, Part D, 205.22
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/valid The content model of this element shall have a value that matches the content model of iwxxm:MeteorologicalAerodromeForecastRecord.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/prevailing-forecast-conditions The XML attribute //iwxxm:MeteorologicalAerodromeForecastRecord/@changeIndicator shall be absent if the forecast describes the prevailing meteorological conditions.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-fm If the meteorological conditions forecast for the aerodrome are expected to change significantly and more or less completely to a different set of conditions, then the XML attribute //iwxxm:MeteorologicalAerodromeForecastRecord/@changeIndicator shall have the value “FROM”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-becmg If the meteorological conditions forecast for the aerodrome are expected to reach or pass through specified values at a regular or irregular rate, then the XML attribute //iwxxm:MeteorologicalAerodromeForecastRecord/@changeIndicator shall have the value “BECOMING”.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-tempo If temporary fluctuations in the meteorological conditions forecast for the aerodrome are expected occur, then the XML attribute //iwxxm:MeteorologicalAerodromeForecastRecord/@changeIndicator shall have the value “TEMPORARY_FLUCTUATIONS”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-prob30 If meteorological conditions forecast for the aerodrome have a 30% probability of occurring, then the XML attribute //iwxxm:MeteorologicalAerodromeForecastRecord/@changeIndicator shall have the value “PROBABILITY_30”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-prob30-tempo If the forecast of temporary fluctuations in meteorological conditions has a 30% probability of occurring, then the XML attribute //iwxxm:MeteorologicalAerodromeForecastRecord/@changeIndicator shall have the value “PROBABILITY_30_TEMPORARY_FLUCTUATIONS”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-prob40 If meteorological conditions forecast for the aerodrome have a 40% probability of occurring, then the XML attribute //iwxxm:MeteorologicalAerodromeForecastRecord/@changeIndicator shall have the value “PROBABILITY_40”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-prob40-tempo If the forecast of temporary fluctuations in meteorological conditions has a 40% probability of occurring, then the XML attribute //iwxxm:MeteorologicalAerodromeForecastRecord/@changeIndicator shall have the value “PROBABILITY_40_TEMPORARY_FLUCTUATIONS”.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/cavok If the conditions associated with CAVOK are forecast, then (i) the XML attribute //iwxxm:MeteorologicalAerodromeForecastRecord/@cloudAndVisibilityOK shall have value “true”; and (ii) the following XML elements shall be absent: //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:prevailingVisibility, //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:prevailingVisibilityOperator, //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:weather and //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:cloud.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/prevailing-visiblity If reported, the prevailing visibility shall be stated using the XML element //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:prevailingVisibility with the unit of measure metres, indicated using the XML attribute //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:prevailingVisibility/@uom with value “m”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/prevailing-visibility-exceeds-10000m If the prevailing visibility exceeds 10000 metres, then the numeric value of XML element //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:prevailingVisibility shall be set to 10000 and the XML element //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:prevailingVisibilityOperator shall have the value “ABOVE”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/prevailing-visibility-comparison-operator If present, the value XML element //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:prevailingVisibilityOperator shall be one of the enumeration: “ABOVE” or “BELOW”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/temperature If reported, the temperature conditions forecast for the aerodrome shall be expressed using the XML element //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:temperature containing a valid child element iwxxm:AerodromeAirTemperatureForecast.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/number-of-temperature-groups No more than two sets of temperature conditions shall be reported.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/cloud If reported, the cloud conditions forecast for the aerodrome shall be expressed using the XML element //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:cloud containing a valid child element iwxxm:AerodromeCloudForecast.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/forecast-weather If forecast weather is reported, the value of XML attribute //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:forecastWeather/@xlink:href shall be the URI of a valid weather phenomenon code from Part D Code table D-6: Aerodrome present or forecast weather.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/number-of-forecast-weather-codes No more than three forecast weather codes shall be reported.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/surface-wind Surface wind conditions forecast for the aerodrome shall be reported using the XML element //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:surfaceWind containing a valid child element iwxxm:AerodromeSurfaceWindForecast.

Note: units of measurement are specified in accordance with Part D, 1.9.

Note: temporary fluctuations in the meteorological conditions occur when those condition reach or pass specified values and last for a period of time less than one hour in each instance and, in the aggregate, cover less than one-half the period during which the fluctuations are forecast to occur (Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 2.3.3).

Note: the use of change groups and time indicators within a TAF is specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1.3 and Table A5-2.

Note: the use of probability groups and time indicators within a TAF is specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1.4 and Table A5-2.

Note: cloud and visibility information is omitted when considered to be insignificant to aeronautical operations at an aerodrome. This occurs when: (i) visibility exceeds 10 kilometres, (ii) no cloud is present below 1500 metres or the minimum sector altitude, whichever is greatest, and there is no cumulonimbus at any height, and (iii) there is no weather of operational significance. These

conditions are referred to as “CAVOK”. Use of CAVOK is specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 2.2.

Note: visibility for aeronautical purposes is defined as the greater of: (i) the greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognized when observed against a bright background; or (ii) the greatest distance at which lights in the vicinity of 1000 candelas can be seen and identified against an unlit background.

Note: prevailing visibility is defined as the greatest visibility value observed which is reached within at least half the horizon circle or within at least half of the surface of the aerodrome. These areas could comprise contiguous or non-contiguous sectors.

Note: the requirements for reporting prevailing visibility conditions within an aerodrome forecast are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1.2.2.

Note: the absence of XML element //iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:prevailingVisibilityOperator indicates that the prevailing visibility has the numeric value reported.

Note: the requirements for reporting the temperature conditions within an aerodrome forecast are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1.2.5.

Note: the requirements for reporting cloud conditions within an aerodrome forecast are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1.2.4.

Note: the requirements for reporting forecast weather within an aerodrome forecast are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1.2.3.

Note: Part D Code table D-6 is published online at http://codes.wmo.int/49-2/AerodromePresentOrForecastWeather.

Note: the requirements for reporting the surface wind conditions within an aerodrome forecast are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1.2.1.

205.24 Requirements Class: Meteorological aerodrome forecast

205.24.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the ‘result’ of the observation describes the aggregated set of meteorological conditions forecast at an aerodrome as appropriate for inclusion in an aerodrome forecast report (TAF), the ‘feature of interest’ is a representative point location within the aerodrome for which the meteorological conditions were forecast and the ‘procedure’ provides the set of information as specified by WMO.

Note: MeteorologicalAerodromeForecast is a subclass of ComplexSamplingMeasurement defined within METCE.

205.24.2 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/49-2/observation-type/IWXXM/1.1/MeteorologicalAerodromeForecast shall conform to all Requirements in Table 62.

205.24.3 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeForecast shall conform to all Requirements of all relevant dependencies in Table 62 with the exception of those requirements listed as superseded in Part D, 205.24.4.

205.24.4 The requirements and dependencies inherited from Requirements class http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement (as specified in Part D, 202.4) listed in Table 63 are superseded by requirements defined herein and shall no longer apply.

Note: XML implementation of iwxxm:MeteorologicalAerodromeForecast is dependent on:

OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation]

Table 62. Requirements class xsd-meteorological forecast

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast	
Target Type	Data instance
Name	Meteorological aerodrome forecast
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation, OMXML clause 7.3
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/sampling, OMXML clause 7.14
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling, OMXML clause 7.15
Dependency	http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement, Part D, 202.4
Dependency	http://icao.int/saf/1.1/req/xsd-aerodrome, Part D, 204.4
Dependency	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record, Part D, 205.23
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-forecast/feature-of-interest The XML element //om:OM_Observation/om:featureOfInterest shall contain a valid child element sams:SF_SpatialSamplingFeature that describes the reference point to which the forecast meteorological conditions apply. The XML element //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:type shall have value "http://www.opengis.net/def/samplingFeatureType/OGC-OM/2.0/SF_SamplingPoint".

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast/sampled-feature The XML element //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature shall contain a valid child element saf:Aerodrome that describes the aerodrome to which the forecast meteorological conditions apply.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast/result If reported, the XML element //om:OM_Observation/om:result shall contain a valid child element iwxxm:MeteorologicalAerodromeForecastRecord that describes the aggregated set of meteorological conditions forecast for the target aerodrome.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast/phenomenon-time The XML element //om:OM_Observation/om:phenomenonTime shall contain a valid child element gml:TimeInstant or gml:TimePeriod that describes the time for which the forecast is valid.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast/result-time The XML element //om:OM_Observation/om:resultTime shall contain a valid child element gml:TimeInstant that describes the time at which the forecast was made available for dissemination.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast/observed-property The XML attribute //om:OM_Observation/om:observedProperty/@xlink:href should have value “http://codes.wmo.int/49-2/observable-property/MeteorologicalAerodromeForecast”.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast/procedure The value of XML element //om:OM_Observation/om:procedure/metce:Process/gml:description should be used to cite the Technical Regulations relating to meteorological aerodrome forecasts.

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/observation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/observation (OMXML clause A.1).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/sampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/sampling (OMXML clause A.12).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/spatialSampling (OMXML clause A.13).

Note: URI http://codes.wmo.int/49-2/observable-property/MeteorologicalAerodromeForecast refers to an XML document that defines the aggregate set of observable properties relevant to an aerodrome forecast.

Note: the Technical Regulations relating to forecasts may be cited as: “Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1: Criteria related to TAF”.

Note: a forecast may be provided for a specific time instant or a time period. Requirements regarding the specification of time for which the forecast is valid are specified at Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1.3.

Note: in the case of NIL report (e.g. to indicate that an anticipated TAF is considered to be “MISSING”), no meteorological conditions are provided. In these cases, the XML element //om:OM_Observation/om:result has no child elements and the XML attribute //om:OM_Observation/om:result/@nilReason is used to indicate why the “result” is absent.

Table 63. Superseded requirements and dependencies from xsd-complex-sampling-measurement

Superseded requirements and dependencies	
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/complexObservation, OMXML clause 7.10
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components, SWE Common 2.0 clause 8.1
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-record-components, SWE Common 2.0 clause 8.2
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-encodings, SWE Common 2.0 clause 8.5
Dependency	http://www.opengis.net/spec/SWE/2.0/req/general-encoding-rules, SWE Common 2.0 clause 9.1
Dependency	http://www.opengis.net/spec/SWE/2.0/req/text-encoding-rules, SWE Common 2.0 clause 9.2
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xml-encoding-rules, SWE Common 2.0 clause 9.3
Requirement	http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement/xmlns-declaration-swe, Part D, 202.4

205.25 Requirements Class: TAF

205.25.1 This requirements class is used to describe the aerodrome forecast report within which a base forecast, and optionally one or more change forecasts, is provided.

Note: the reporting requirements for aerodrome forecasts are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3 and Appendix 5, [C.3.1] 1.

205.25.2 XML elements describing aerodrome forecast reports shall conform to all Requirements specified in Table 64.

205.25.3 XML elements describing aerodrome forecast reports shall conform to all Requirements of all relevant dependencies specified in Table 64.

Table 64. Requirements class xsd-taf

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-taf	
Target Type	Data instance
Name	TAF
Dependency	http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast, Part D, 205.24
Requirement	http://icao.int/iwxxm/1.1/req/xsd-taf/valid The content model of this element shall have a value that matches the content model of iwxxm:TAF.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-taf/status The status of the TAF shall be indicated using the XML attribute //iwxxm:TAF/@status with the value being one of the enumeration: “NORMAL”, “AMENDMENT”, “CANCELLATION”, “CORRECTION” or “MISSING”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-taf/issue-time The XML element //iwxxm:TAF/iwxxm:issueTime shall contain a valid child element gml:TimeInstant that describes the time at which the TAF was issued.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-taf/base-forecast If the prevailing forecast conditions for the valid period of the TAF are reported, then i) the XML element //iwxxm:TAF/iwxxm:baseForecast shall contain a valid child element om:OM_Observation of type MeteorologicalAerodromeForecast; ii) the value of the XML attribute //iwxxm:TAF/iwxxm:baseForecast/om:OM_Observation/om:type/@xlink:href shall be the URI "http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeForecast"; and iii) the XML attribute //iwxxm:TAF/iwxxm:baseForecast/om:OM_Observation/om:result/iwxxm:MeteorologicalAerodromeForecastRecord/@changeIndicator shall be absent.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-taf/change-forecast If change forecasts or alternative forecasts with probability of occurrence are reported, then i) the XML element //iwxxm:TAF/iwxxm:changeForecast shall contain a valid child element om:OM_Observation of type MeteorologicalAerodromeForecast; ii) the value of the XML attribute //iwxxm:TAF/iwxxm:changeForecast/om:OM_Observation/om:type/@xlink:href shall be the URI "http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeForecast"; iii) XML element //iwxxm:TAF/iwxxm:changeForecast/om:OM_Observation/om:result/iwxxm:MeteorologicalAerodromeForecastRecord/iwxxm:temperature shall be absent; and iv) the XML attribute //iwxxm:TAF/iwxxm:baseForecast/om:OM_Observation/om:result/iwxxm:MeteorologicalAerodromeForecastRecord/@changeIndicator shall be one of the enumeration: "BECOMING", "TEMPORARY_FLUCTUATIONS", "FROM", "PROBABILITY_30", "PROBABILITY_30_TEMPORARY_FLUCTUATIONS", "PROBABILITY_40", or "PROBABILITY_40_TEMPORARY_FLUCTUATIONS".
Requirement	http://icao.int/iwxxm/1.1/req/xsd-taf/unique-subject-aerodrome The base forecast and, if reported, change forecasts shall refer to the same aerodrome. All values of XML element //iwxxm:TAF/*/om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature/saf:Aerodrome/gml:identifier within the TAF shall be identical.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-taf/status-normal If the status of the TAF is “NORMAL” (as specified by XML attribute //iwxxm:TAF/@status), then: i) the prevailing meteorological conditions anticipated during the valid period of the TAF shall be reported using the XML element //iwxxm:TAF/iwxxm:baseForecast; ii) the valid time period of the TAF shall be given using the XML element //iwxxm:TAF/iwxxm:validTime/gml:TimePeriod iii) the XML element //iwxxm:TAF/iwxxm:previousReportAerodrome shall be absent; and iv) the XML element //iwxxm:TAF/iwxxm:previousReportValidPeriod shall be absent.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-taf/status-amendment-or-correction If the status of the TAF is “AMENDMENT” or “CORRECTION” (as specified by XML attribute //iwxxm:TAF/@status), then: i) the prevailing meteorological conditions anticipated during the valid period of the TAF shall be reported using the XML element //iwxxm:TAF/iwxxm:baseForecast; ii) the valid time period of the TAF shall be given using the XML element //iwxxm:TAF/iwxxm:validTime/gml:TimePeriod; and iii) the valid time period for the TAF that has been amended or corrected shall be reported using the XML element //iwxxm:TAF/iwxxm:previousReportValidPeriod/gml:TimePeriod.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-taf/status-cancellation If the status of the TAF is “CANCELLATION” (as specified by XML attribute //iwxxm:TAF/@status), then: i) the XML element //iwxxm:TAF/iwxxm:baseForecast shall be absent; ii) the XML element //iwxxm:TAF/iwxxm:changeForecast shall be absent; iii) the time period for which TAF reports at the subject aerodrome are cancelled shall be given using the XML element //iwxxm:TAF/iwxxm:validTime/gml:TimePeriod iv) the aerodrome for which TAF reports are cancelled shall be reported using the XML element //iwxxm:TAF/iwxxm:previousReportAerodrome/saf:Aerodrome; and v) the valid time period for the TAF that has been cancelled shall be reported using the XML element //iwxxm:TAF/iwxxm:previousReportValidPeriod/gml:TimePeriod.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-taf/nil-report-status-missing If the status of the TAF is “MISSING” (as specified by XML attribute //iwxxm:TAF/@status), then: i) the XML element //iwxxm:TAF/iwxxm:baseForecast shall be have valid child element om:OM_Observation of type MeteorologicalAerodromeForecast ii) the value of XML element //iwxxm:TAF/iwxxm:baseForecast/om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature/saf:Aerodrome shall indicate the aerodrome for which the TAF is missing; iii) the XML element //iwxxm:TAF/iwxxm:baseForecast/om:OM_Observation/om:result shall have no child elements and XML attribute //iwxxm:TAF/iwxxm:baseForecast/om:OM_Observation/om:result/@nilReason shall provide an appropriate nil-reason; iv) the XML element //iwxxm:TAF/iwxxm:changeForecast shall be absent; v) the XML element //iwxxm:TAF/iwxxm:validTime shall be absent; vi) the XML element //iwxxm:TAF/iwxxm:previousReportAerodrome shall be absent; and vii) the XML element //iwxxm:TAF/iwxxm:previousReportValidPeriod shall be absent.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-taf/number-of-change-forecasts The number of change forecasts should be kept to a minimum, and no more than five change forecasts should be reported in normal circumstances.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-taf/issue-time-matches-result-time The TAF issue time (specified by XML element //iwxxm:TAF/iwxxm:issueTime/gml:TimeInstant) should match the result time for each of the forecasts provided within the TAF (specified by XML element //iwxxm:TAF/*/om:OM_Observation/om:resultTime/gml:TimeInstant).
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-taf/valid-time-includes-all-phenomenon-times The valid times of all forecasts included in the TAF (specified by XML element //iwxxm:TAF/*/om:OM_Observation/om:phenomenonTime/*) should occur within the valid time period of the TAF (specified by XML element //iwxxm:TAF/iwxxm:validTime/gml:TimePeriod).

Requirements Class	
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-taf/status-amendment-or-correction-previous-aerodrome If the status of the TAF is “AMENDMENT” or “CORRECTION” (as specified by XML attribute //iwxxm:TAF/@status), then the aerodrome that was the subject of the TAF that has been amended or corrected should be reported using the XML element //iwxxm:TAF/iwxxm:previousReportAerodrome/saf:Aerodrome.

Note: the requirements relating to the reporting of change forecasts are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1.3.

Note: the requirements relating to the reporting of alternative forecasts with probability of occurrence are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1.4.

Note: guidance regarding the number of change forecasts and alternative forecasts is given in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 5, [C.3.1.] 1.5.

Note: a report with status “MISSING” indicates that a routine report has not been provided on the anticipated timescales. Such a report does not contain details of any forecast meteorological conditions and is often referred to as a “NIL” report.

Note: within an XML encoded TAF it is likely that only one instance of saf:Aerodrome will physically be present; subsequent assertions about the aerodrome may use xlinks to refer to the previously defined saf:Aerodrome element in order to keep the XML document size small. As such, validation of requirement http://icao.int/iwxxm/1.1/req/xsd-taf/unique-subject-aerodrome is applied once any xlinks, if used, have been resolved.

Note: Part D Code table D-1 provides a set of nil reason codes and is published at http://codes.wmo.int/common/nil.

205.26 Requirements Class: Evolving meteorological condition

205.26.1 This requirements class is used to describe the presence of a specific SIGMET phenomenon such as volcanic ash or thunderstorm, along with expected changes to the intensity of the phenomenon, its speed and direction of motion. The geometric extent of the SIGMET phenomenon is specified as a two dimensional horizontal region with bounded vertical extent.

205.26.2 XML elements describing the characteristics of a SIGMET phenomenon shall conform to all Requirements specified in Table 65.

205.26.3 XML elements describing the characteristics of a SIGMET phenomenon shall conform to all Requirements of all relevant dependencies specified in Table 65.

Table 65. Requirements class xsd-evolving-meteorological-condition

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition	
Target Type	Data instance
Name	Evolving meteorological condition
Dependency	http://icao.int/saf/1.1/req/xsd-airspace-volume, Part D, 204.8
Requirement	http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition/valid The content model of this element shall have a value that matches the content model of iwxxm:EvolvingMeteorologicalCondition.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition/intensity-change The anticipated change in intensity of the SIGMET phenomenon shall be indicated using the XML attribute //iwxxm:EvolvingMeteorologicalCondition/@intensityChange with the value being one of the enumeration: “NO_CHANGE”, “WEAKEN” or “INTENSIFY”.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition/geometry The geometric extent of the SIGMET phenomenon shall be reported using the XML element //iwxxm:EvolvingMeteorologicalCondition/iwxxm:geometry with valid child element saf:AirspaceVolume.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition/speed-of-motion The speed of motion of the SIGMET phenomenon shall be reported using the XML element //iwxxm:EvolvingMeteorologicalCondition/iwxxm:speedOfMotion with the unit of measure metres per second, knots or kilometres per hour. The unit of measure shall be indicated using the XML attribute //iwxxm:EvolvingMeteorologicalCondition/iwxxm:speedOfMotion/@uom with value “m/s” (metres per second), “[kn_i]” (knots) or “km/h” (kilometres per hour).

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition/direction-of-motion If reported, the angle between true north and the direction of motion of the SIGMET phenomenon shall be given in degrees using the XML element //iwxxm:EvolvingMeteorologicalCondition/iwxxm:directionOfMotion. The unit of measure shall be indicated using the XML attribute //iwxxm:EvolvingMeteorologicalCondition/iwxxm:directionOfMotion/@uom with value “deg”.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition/stationary-phenomenon If the SIGMET phenomenon is not moving, (indicated by the XML element //iwxxm:EvolvingMeteorologicalCondition/iwxxm:speedOfMotion having numeric value zero) XML element //iwxxm:EvolvingMeteorologicalCondition/iwxxm:directionOfMotion should be absent.

Note: units of measurement are specified in accordance with Part D, 1.9.

Note: the True North is the north point at which the meridian lines meet.

205.27 Requirements Class: SIGMET evolving condition analysis

205.27.1 This requirements class is used to describe the details of how the characteristics of a SIGMET phenomenon were evaluated and is based on the observation pattern from ISO 19156:2011, Geographic information – Observations and measurements. This requirements class is applicable to both the observation and forecasting of SIGMET phenomenon characteristics.

205.27.2 This requirements class restricts the content model of om:OM_Observation such that the ‘result’ of the observation describes the characteristics of a SIGMET phenomenon (including geometric extent, expected intensity change, speed and direction of motion), the ‘feature of interest’ is the bounded extent of the airspace for which the SIGMET report is issued and the ‘procedure’ provides the set of information as specified by WMO.

Note: SIGMETEvolvingConditionAnalysis is a subclass of SamplingObservation defined within METCE.

205.27.3 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/SIGMETEvolvingConditionAnalysis shall conform to all Requirements in Table 66.

205.27.4 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/SIGMETEvolvingConditionAnalysis shall conform to all Requirements of all relevant dependencies in Table 66.

Note: XML implementation of iwxxm:SIGMETEvolvingConditionAnalysis is dependent on:

OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation]

Table 66. Requirements class xsd-sigmet-evolving-condition-analysis

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-sigmet-evolving-condition-analysis	
Target Type	Data instance
Name	SIGMET evolving condition analysis
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation, OMXML clause 7.3
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/sampling, OMXML clause 7.14
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling, OMXML clause 7.15
Dependency	http://def.wmo.int/metce/2013/req/xsd-sampling-observation, Part D, 202.6
Dependency	http://icao.int/saf/1.1/req/xsd-airspace, Part D, 204.9
Dependency	http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition, Part D, 205.26
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet-evolving-condition-analysis/feature-of-interest The XML element //om:OM_Observation/om:featureOfInterest shall contain a valid child element sams:SF_SpatialSamplingFeature that describes the horizontal extent of the airspace for which the SIGMET report is issued – a sampling surface. The XML element //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:type shall have value "http://www.opengis.net/def/samplingFeatureType/OGC-OM/2.0/SF_SamplingSurface".
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet-evolving-condition-analysis/sampled-feature The XML element //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature shall contain a valid child element saf:Airspace that describes the airspace for which the SIGMET report is issued.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet-evolving-condition-analysis/result If reported, the XML element //om:OM_Observation/om:result shall contain a valid child element iwxxm:EvolvingMeteorologicalCondition that describes the characteristics of the SIGMET phenomenon (geometric extent, expected intensity change, speed and direction of motion).
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet-evolving-condition-analysis/phenomenon-time The XML element //om:OM_Observation/om:phenomenonTime shall contain a valid child element gml:TimeInstant that describes the time at which the SIGMET phenomenon was observed or the time for which the characteristics of the SIGMET phenomenon have been forecast.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet-evolving-condition-analysis/result-time The XML element //om:OM_Observation/om:resultTime shall contain a valid child element gml:TimeInstant that describes the time at which the details of the SIGMET phenomenon were made available for dissemination.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-sigmet-evolving-condition-analysis/observed-property The XML attribute //om:OM_Observation/om:observedProperty/@xlink:href should have a value that is the URI of a valid term from Part D Code table D-9: Significant weather phenomena.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-sigmet-evolving-condition-analysis/procedure The value of XML element //om:OM_Observation/om:procedure/metce:Process/gml:description should be used to cite the Technical Regulations relating to provision of SIGMET reports.

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/observation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/observation (OMXML clause A.1).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/sampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/sampling (OMXML clause A.12).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/spatialSampling (OMXML clause A.13).

Note: Part D Code table D-9 is published online at http://codes.wmo.int/49-2/SigWxPhenomena.

Note: the Technical Regulations relating to provision of SIGMET reports may be cited as: "Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 6, [C.3.1.] 1: Specifications related to SIGMET information".

Note: in the case of SIGMET cancellation, no characteristics of a SIGMET phenomenon are provided. In these cases, the XML element //om:OM_Observation/om:result has no child elements and the XML attribute //om:OM_Observation/om:result/@nilReason is used to indicate why the "result" is absent.

205.28 Requirements Class: Meteorological position

205.28.1 This requirements class is used to describe the forecast position and extent of a specific SIGMET phenomenon, such as volcanic ash or thunderstorm, at the end of the valid period of the SIGMET report. The geometric extent of the SIGMET phenomenon is specified as a two dimensional horizontal region with bounded vertical extent.

205.28.2 XML elements describing only the geometry of a SIGMET phenomenon shall conform to all Requirements specified in Table 67.

205.28.3 XML elements describing only the geometry of a SIGMET phenomenon shall conform to all Requirements of all relevant dependencies specified in Table 67.

Table 67. Requirements class xsd-meteorological-position

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-meteorological-position	
Target Type	Data instance
Name	Meteorological position
Dependency	http://icao.int/saf/1.1/req/xsd-airspace-volume, Part D, 204.8
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-position/valid The content model of this element shall have a value that matches the content model of iwxxm:MeteorologicalPosition.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-position/geometry The geometric extent of the SIGMET phenomenon shall be reported using the XML element //iwxxm:MeteorologicalPosition/iwxxm:geometry with valid child element saf:AirspaceVolume.

205.29 Requirements Class: Meteorological position collection

205.28.1 This requirements class is used to describe a collection of geometries for a specific SIGMET phenomenon, such as volcanic ash or thunderstorm, at the end of the valid period of the SIGMET report.

205.28.2 XML elements describing a collection of geometries for a SIGMET phenomenon shall conform to all Requirements specified in Table 68.

205.28.3 XML elements describing a collection of geometries for a SIGMET phenomenon shall conform to all Requirements of all relevant dependencies specified in Table 68.

Table 68. Requirements class xsd-meteorological-position-collection

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-meteorological-position-collection	
Target Type	Data instance
Name	Meteorological position collection
Dependency	http://icao.int/iwxxm/1.1/req/xsd-meteorological-position, Part D, 205.28
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-position-collection/valid The content model of this element shall have a value that matches the content model of iwxxm:MeteorologicalPositionCollection.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-meteorological-position-collection/members If reported, the geometries for a specific SIGMET phenomenon shall be provided using the XML element //iwxxm:MeteorologicalPositionCollection/iwxxm:member with valid child element iwxxm:MeteorologicalPosition.

205.30 Requirements Class: SIGMET position analysis

205.30.1 This requirements class is used to describe the details of how the forecast position of a SIGMET phenomenon at the end of the valid period of a SIGMET report was evaluated.

205.30.2 This requirements class restricts the content model of om:OM_Observation such that the ‘result’ of the observation describes the collection of forecast positions of a specific SIGMET phenomenon, the ‘feature of interest’ is the bounded extent of the airspace for which the SIGMET report is issued and the ‘procedure’ provides the set of information as specified by WMO.

Note: SIGMETPositionAnalysis is a subclass of SamplingObservation defined within METCE.

205.30.3 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/SIGMETPositionAnalysis shall conform to all Requirements in Table 69.

205.30.4 Instances of om:OM_Observation with element om:type specifying http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/SIGMETPositionAnalysis shall conform to all Requirements of all relevant dependencies in Table 69.

Note: XML implementation of iwxxm:SIGMETPositionAnalysis is dependent on:

OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation]

Table 69. Requirements class xsd-sigmet-position-analysis

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-sigmet-position-analysis	
Target Type	Data instance
Name	SIGMET position analysis
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation, OMXML clause 7.3
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/sampling, OMXML clause 7.14
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling, OMXML clause 7.15
Dependency	http://def.wmo.int/metce/2013/req/xsd-sampling-observation, Part D, 202.6
Dependency	http://icao.int/saf/1.1/req/xsd-airspace, Part D, 204.9
Dependency	http://icao.int/iwxxm/1.1/req/xsd-meteorological-position-collection, Part D, 205.29
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet-position-analysis/feature-of-interest The XML element //om:OM_Observation/om:featureOfInterest shall contain a valid child element sams:SF_SpatialSamplingFeature that describes the horizontal extent of the airspace for which the SIGMET report is issued – a sampling surface. The XML element //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:type shall have value "http://www.opengis.net/def/samplingFeatureType/OGC-OM/2.0/SF_SamplingSurface".

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet-position-analysis/sampled-feature The XML element //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature shall contain a valid child element saf:Airspace that describes the airspace for which the SIGMET report is issued.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet-position-analysis/result The XML element //om:OM_Observation/om:result shall contain a valid child element iwxxm:MeteorologicalPositionCollection that describes the collection of forecast positions of a specific SIGMET phenomenon.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet-position-analysis/phenomenon-time The XML element //om:OM_Observation/om:phenomenonTime shall contain a valid child element gml:TimeInstant that describes the time for which the collection of positions of the SIGMET phenomenon have been forecast.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet-position-analysis/result-time The XML element //om:OM_Observation/om:resultTime shall contain a valid child element gml:TimeInstant that describes the time at which the details of the SIGMET phenomenon positions were made available for dissemination.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-sigmet-position-analysis/observed-property The XML attribute //om:OM_Observation/om:observedProperty/@xlink:href should have a value that is the URI of a valid term from Part D Code table D-9: Significant weather phenomena.
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-sigmet-position-analysis/procedure The value of XML element //om:OM_Observation/om:procedure/metce:Process/gml:description should be used to cite the Technical Regulations relating to provision of SIGMET reports.

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/observation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/observation (OMXML clause A.1).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/sampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/sampling (OMXML clause A.12).

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/spatialSampling (OMXML clause A.13).

Note: Part D Code table D-9 is published online at http://codes.wmo.int/49-2/SigWxPhenomena.

Note: the Technical Regulations relating to provision of SIGMET reports may be cited as: "Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 6, [C.3.1.] 1: Specifications related to SIGMET information".

205.31 Requirements Class: SIGMET

205.31.1 This requirements class is used to describe the SIGMET report within which the characteristics of a specific SIGMET phenomenon are described.

Note: the reporting requirements for SIGMETs are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 6, [C.3.1] 1.

205.31.2 XML elements describing SIGMET reports shall conform to all Requirements specified in Table 70.

205.31.3 XML elements describing SIGMET reports shall conform to all Requirements of all relevant dependencies specified in Table 70.

Table 70. Requirements class xsd-sigmet

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-sigmet	
Target Type	Data instance
Name	SIGMET
Dependency	http://icao.int/saf/1.1/req/xsd-aeronautical-service-provision-units, Part D, 204.7
Dependency	http://icao.int/iwxxm/1.1/req/xsd-sigmet-evolving-condition-analysis, Part D, 205.27
Dependency	http://icao.int/iwxxm/1.1/req/xsd-sigmet-position-analysis, Part D, 205.30
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet/valid The content model of this element shall have a value that matches the content model of iwxxm:SIGMET.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet/status The status of the SIGMET shall be indicated using the XML attribute @status with the value being one of the enumeration: "NORMAL", or "CANCELLATION".

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet/issuing-air-traffic-service-unit The air traffic services unit responsible for the subject airspace shall be indicated using the XML element iwxxm:issuingAirTrafficServicesUnit with a valid child element saf:Unit.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet/originating-meteorological-watch-office The meteorological watch office that originated the SIGMET report shall be indicated using the XML element iwxxm:originatingMeteorologicalWatchOffice with a valid child element saf:Unit. The value of XML element iwxxm:issuingAirTrafficServicesUnit/saf:Unit/saf:type shall be “MWO” (Meteorological Watch Office).
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet/sequence-number The sequence number of this SIGMET report shall be indicated using XML element iwxxm:sequenceNumber.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet/valid-period The period of validity of this SIGMET report shall be indicated using XML element iwxxm:validPeriod with valid child element gml:TimePeriod.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet/phenomenon The XML attribute iwxxm:phenomenon/@xlink:href shall have a value that is the URI of a valid term from Part D Code table D-9: Significant weather phenomena.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet/unique-subject-airspace All SIGMET analyses included in the report shall refer to the same airspace. All values of XML element //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature/saf:Airspace/gml:identifier within the SIGMET shall be identical.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet/analysis If reported, XML element iwxxm:analysis shall contain a valid child element om:OM_Observation of type SIGMETEvolvingConditionAnalysis. The value of XML attribute iwxxm:analysis/om:OM_Observation/om:type/@xlink:href shall be the URI “http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/SIGMETEvolvingConditionAnalysis”.

Requirements Class	
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet/forecast-position-analysis If reported, the forecast position of the phenomenon shall be reported using the XML element iwxxm:forecastPositionAnalysis with valid child element om:OM_Observation of type SIGMETPositionAnalysis. The value of XML attribute iwxxm:forecastPositionAnalysis/om:OM_Observation/om:type/@xlink:href shall be the URI "http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/SIGMETPositionAnalysis".
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet/status-normal If the status of the SIGMET is "NORMAL" (as specified by XML attribute @status), then: i) the characteristics of the SIGMET phenomenon shall be reported using one or more of the XML element iwxxm:analysis; ii) each XML element iwxxm:analysis shall contain a valid element iwxxm:analysis/om:OM_Observation/om:result/iwxxm:EvolvingMeteorologicalCondition within which the characteristics of the SIGMET phenomenon are described; iii) the XML element iwxxm:cancelledSequenceNumber shall be absent; and iv) the XML element iwxxm:cancelledValidPeriod shall be absent.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-sigmet/status-cancellation If the status of the SIGMET is "CANCELLATION" (as specified by XML attribute @status), then: i) the details of the airspace for which the SIGMET has been cancelled shall be provided by a single instance of XML element iwxxm:analysis; ii) the XML element iwxxm:analysis/om:OM_Observation/om:result shall have no child elements and XML attribute iwxxm:analysis/om:OM_Observation/om:result/@nilReason shall provide an appropriate nil-reason; iii) the value XML element iwxxm:cancelledSequenceNumber shall indicated the sequence number of the SIGMET that has been cancelled; and iv) the XML element iwxxm:cancelledValidPeriod shall have a valid child element gml:TimePeriod that indicates the validity period of the SIGMET that has been cancelled.

Requirements Class	
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-sigmet/issuing-air-traffic-service-unit-type The value of XML element //iwxxm:SIGMET/iwxxm:issuingAirTrafficServicesUnit/saf:Unit/saf:type should be one of the enumeration: “ATSU” (Air Traffic Services Unit) or “FIC” (Flight Information Centre).
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-sigmet/valid-period-start-matches-result-time The start time of the validity period of the SIGMET report (expressed using XML element //iwxxm:validPeriod/gml:TimePeriod/gml:beginPosition) should match the result time of each SIGMET analysis included within the report (expressed using XML element //om:OM_Observation/om:resultTime/gml:TimeInstant/gml:timePosition).
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-sigmet/valid-time-includes-all-phenomenon-times The observation and/or forecast times of all SIGMET analyses and, if reported, forecast position analyses included in the report (specified by XML element //om:OM_Observation/om:phenomenonTime/*) should occur within the valid time period of the SIGMET (specified by XML element //iwxxm:validPeriod/gml:TimePeriod).
Recommendation	http://icao.int/iwxxm/1.1/req/xsd-sigmet/7-point-definition-of-airspace-volume The horizontal extent of any airspace volumes enclosing a SIGMET phenomenon (reported using XML element //om:OM_Observation/om:result/*/iwxxm:geometry/saf:AirspaceVolume/saf:horizontalProjection) should use no more than seven points to define the bounding polygon.

Note: requirements relating to sequence numbers within SIGMET reports are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 6, [C.3.1.] 1.1.3.

Note: requirements relating to reporting of the SIGMET phenomenon are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 6, [C.3.1.] 1.1.4.

Note: a forecast position may be provided for a volcanic ash cloud, the centre of a tropical cyclone or other hazardous phenomena at the end of the validity period of the SIGMET message.

Note: within an XML encoded SIGMET it is likely that only one instance of saf:Airspace will physically be present; subsequent assertions about the airspace may use xlinks to refer to the previously defined saf:Airspace element in order to keep the XML document size small. As such, validation of requirement http://icao.int/iwxxm/1.1/req/xsd-sigmet/unique-subject-airspace is applied once any xlinks, if used, have been resolved.

Note: Part D Code table D-1 provides a set of nil reason codes and is published at http://codes.wmo.int/common/nil.

Note: Part D Code table D-9 is published online at http://codes.wmo.int/49-2/SigWxPhenomena.

205.32 Requirements Class: Volcanic ash SIGMET

205.32.1 This requirements class is used to describe the Volcanic Ash (VA) SIGMET report, which includes additional information about the source volcano and the forecast position of the volcanic ash at the end of the validity period of the SIGMET.

205.32.2 XML elements describing VA-SIGMET reports shall conform to all Requirements specified in Table 71.

205.32.3 XML elements describing VA-SIGMET reports shall conform to all Requirements of all relevant dependencies specified in Table 71.

Table 71. Requirements class xsd-volcanic-ash-sigmet

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-volcanic-ash-sigmet	
Target Type	Data instance
Name	Volcanic ash SIGMET
Dependency	http://def.wmo.int/metce/2013/req/xsd-erupting-volcano, Part D, 202.8
Dependency	http://icao.int/iwxxm/1.1/req/xsd-sigmet, Part D, 205.31
Requirement	http://icao.int/iwxxm/1.1/req/xsd-volcanic-ash-sigmet/valid The content model of this element shall have a value that matches the content model of iwxxm:VolcanicAshSIGMET.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-volcanic-ash-sigmet/source-volcano Details of the volcano that is the source of the volcanic ash shall be reported using the XML element iwxxm:eruptingvolcano with valid child element metce:Volcano (or element in the substitution group of metce:Volcano).
Requirement	http://icao.int/iwxxm/1.1/req/xsd-volcanic-ash-sigmet/phenomenon The XML attribute iwxxm:phenomenon/@xlink:href shall have a value that is the URI “http://codes.wmo.int/49-2/SigWxPhenomena/VA”.

205.33 Requirements Class: Tropical cyclone SIGMET

205.33.1 This requirements class is used to describe the Tropical Cyclone (TC) SIGMET report, which includes additional information about the tropical cyclone itself and the forecast position of the tropical cyclone at the end of the validity period of the SIGMET.

205.33.2 XML elements describing TC-SIGMET reports shall conform to all Requirements specified in Table 72.

205.33.2 XML elements describing TC-SIGMET reports shall conform to all Requirements of all relevant dependencies specified in Table 72.

Table 72. Requirements class xsd-tropical-cyclone-sigmet

Requirements Class	
http://icao.int/iwxxm/1.1/req/xsd-tropical-cyclone-sigmet	
Target Type	Data instance
Name	Tropical cyclone SIGMET
Dependency	http://def.wmo.int/metce/2013/req/xsd-tropical-cyclone, Part D, 202.9
Dependency	http://icao.int/iwxxm/1.1/req/xsd-sigmet, Part D, 205.31
Requirement	http://icao.int/iwxxm/1.1/req/xsd-tropical-cyclone-sigmet/valid The content model of this element shall have a value that matches the content model of iwxxm:TropicalCycloneSIGMET.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-tropical-cyclone-sigmet/cyclone Details of the tropical cyclone shall be reported using the XML element iwxxm:tropicalCyclone with valid child element metce:TropicalCyclone.
Requirement	http://icao.int/iwxxm/1.1/req/xsd-tropical-cyclone-sigmet/phenomenon The XML attribute iwxxm:phenomenon/@xlink:href shall have a value that is the URI “http://codes.wmo.int/49-2/SigWxPhenomena/TC”.

APPENDIX A: CODE TABLES

CODE TABLE D-1: NIL REASONS

Nil-reason terms are used to provide an explanation for recording a missing (or void) value within a data product. Terms are drawn from authorities in addition to WMO including ISO/TC 211 (from ISO 19136:2007 Geography markup language clause 8.2.3.1; published on their behalf by the Open Geospatial Consortium). The *code-space* indicates the authority under which the nil-reason terms are published. A URI for each nil-reason term is composed by appending the *notation* to the *code*-space. As an example, the URI of *notDetectedByAutoSystem* is http://codes.wmo.int/common/nil/notDetectedByAutoSystem. The URI is also a URL providing additional information about the associated nil-reason term. This code table is published at http://codes.wmo.int/common/nil.

Label	Notation	Code-space	Description
Above detection range	AboveDetectionRange	http://www.opengis.net/def/nil/OGC/0/	The value was above the detection range of the instrument used to estimate it.
Below detection range	BelowDetectionRange	http://www.opengis.net/def/nil/OGC/0/	The value was above the detection range of the instrument used to estimate it.
Inapplicable	inapplicable	http://www.opengis.net/def/nil/OGC/0/	There is no value.
Missing	missing	http://www.opengis.net/def/nil/OGC/0/	The correct value is not readily available to the sender of this data. Furthermore, a correct value may not exist.
No significant change (NOSIG)	noSignificantChange	http://codes.wmo.int/common/nil/	No significant change is expected to occur.
Nothing detected by automated system	notDetectedByAutoSystem	http://codes.wmo.int/common/nil/	The automated observing system did not detect a value (e.g. no cloud detected ‘NCD’).
Not observable	notObservable	http://codes.wmo.int/common/nil/	A system failure, sensor failure, or sensor obstruction prevented the intended observation of the value.

Label	Notation	Code-space	Description
Nothing of operational significance	nothingOfOperationalSignificance	http://codes.wmo.int/common/nil/	Nothing was observed or forecast of operational significance (e.g. nil significant cloud 'NSC', nil significant weather 'NSW').
Template	template	http://www.opengis.net/def/nil/OGC/0/	The value will be available later.
Unknown	unknown	http://www.opengis.net/def/nil/OGC/0/	The correct value is not known to, and not computable by, the sender of the data. However, a correct value probably exists.
Withheld	withheld	http://www.opengis.net/def/nil/OGC/0/	The value is not divulged.

CODE TABLE D-2: PHYSICAL QUANTITY KINDS

The Unique Resource Identifier (URI) of each physical quantity kind is composed by the prefix http://codes.wmo.int/common/quantity-kind/ and the notation. As an example the URI of airTemperature is http://codes.wmo.int/common/quantity-kind/airTemperature . The URI can be used in the XML code format and is also a URL providing comprehensive information regarding the physical quantity kind.

Meteorological quantities

Label	Notation	Description	Dimensions
Air temperature	airTemperature	The temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation.	Θ
Atmospheric pressure	atmosphericPressure	The atmospheric pressure on a given surface is the force per unit area exerted by virtue of the weight of the atmosphere above. The pressure is thus equal to the weight of a vertical column of air above a horizontal projection of the surface, extending to the outer limit of the atmosphere.	$ML^{-1}T^{-2}$
Dew-point temperature	dewPointTemperature	The temperature to which a given air parcel must be cooled at constant pressure and constant water vapour content in order for saturation to occur.	Θ
Height of base of cloud	heightOfBaseOfCloud	For a given cloud or cloud layer, vertical distance (measured from local ground surface) of the lowest level in the atmosphere at which the air contains a perceptible quantity of cloud particles.	L
Horizontal visibility	horizontalVisibility	The greatest distance determined in the horizontal plane at the ground surface that prominent objects can be seen and identified by unaided, normal eyes.	L
Maximum wind gust speed	maximumWindGustSpeed	Nominal maximum speed of wind during a given period; usually determined as a mean wind speed over a short duration (e.g. 1-minute) within a longer period (e.g. 10-minutes).	LT^{-1}
Sea surface temperature	seaSurfaceTemperature	Temperature of the sea water at surface.	Θ
Vertical visibility	verticalVisilibity	Maximum distance at which an observer can seee and identify an object on the same vertical as himself, above or below.	L

Oceanographic quantities

Label	Notation	Description	Dimensions
Sea surface temperature	seaSurfaceTemperature	Temperature of the sea water at surface.	Θ

Aeronautical quantities

Label	Notation	Description	Dimensions
Aerodrome maximum wind gust speed	aerodromeMaximumWindGustSpeed	Maximum wind speed in the 10 minute period of observation. It is reported only if exceeds the mean speed by 5 m s^{-1} (10 knots).	LT^{-1}
Aerodrome mean wind direction	aerodromeMeanWindDirection	The mean true direction in degrees from which the wind is blowing over the 10-minute period immediately preceding the observation. When the 10-minute period includes a marked discontinuity in the wind characteristics (1), only data after the discontinuity shall be used for mean wind direction and variations of the wind direction, hence the time interval in these circumstances shall be correspondingly reduced.	dimensionless
Aerodrome mean wind speed	aerodromeMeanWindSpeed	The mean speed of the wind over the 10-minute period immediately preceding the observation. When the 10-minute period includes a marked discontinuity in the wind characteristics (1), only data after the discontinuity shall be used for obtaining mean wind speed, hence the time interval in these circumstances shall be correspondingly reduced.	LT^{-1}
Aerodrome minimum horizontal visibility	aerodromeMinimumHorizontalVisibility	The minimum horizontal visibility that is reported when the horizontal visibility is not the same in different directions and when the minimum visibility is different from the prevailing visibility, and less than 1500 metres or less than 50% of the prevailing visibility, and less than 5000 metres.	L
Aerodrome minimum visibility direction	aerodromeMinimumVisibilityDirection	When the minimum horizontal visibility is reported, its general direction in relation to the aerodrome reference point has to be reported and indicated by reference to one of the eight points of the compass. If the minimum visibility is observed in more than one direction, the Dv shall represent the most operationally significant direction.	dimensionless
Aeronautical prevailing horizontal visibility	aeronauticalPrevailingHorizontalVisibility	The greatest visibility value, observed in accordance with the definition of “visibility”, which is reached within at least half the horizon circle or within at least half of the surface of the aerodrome. These areas could comprise contiguous or non-contiguous sectors.	L
Aeronautical visibility	aeronauticalVisibility	The greater of: (a) The greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognized when observed against a bright background; (b) The greatest distance at which lights in the vicinity of 1000 candelas can be seen and identified against an unlit background.	L

Label	Notation	Description	Dimensions
Altimeter setting (QNH)	altimeterSettingQnh	Altimeter setting (also known as QNH) is defined as barometric pressure adjusted to sea level. It is a pressure setting used by pilots, air traffic control (ATC), and low frequency weather beacons to refer to the barometric setting which, when set on an aircraft's altimeter, will cause the altimeter to read altitude above mean sea level within a certain defined region.	$ML^{-1}T^{-2}$
Depth of runway deposit	depthOfRunwayDeposit	Depth of deposit on surface of runway	L
Runway contamination coverage	runwayContaminationCoverage	Proportion of runway that is contaminated. A runway is considered to be contaminated when more than 25% of the runway surface area (whether in isolated areas or not) within the required length and width being used is covered by the following: (a) Surface water more than 3 mm deep, or by slush or loose snow equivalent to more than 3 mm of water; (b) Snow which has been compressed into a solid mass which resists further compression and will hold together or break into lumps if picked up (compacted snow); or (c) Ice, including wet ice.	dimensionless
Runway friction coefficient	runwayFrictionCoefficient	Quantitative assessment of friction coefficient of runway surface.	dimensionless
Runway visual range (RVR)	runwayVisualRangeRvr	The range over which the pilot of an aircraft on the centre line of a runway can see the runway surface markings or the lights delineating the runway or identifying its centre line.	L

NOTES:

(1) A marked discontinuity occurs when there is an abrupt and sustained change in wind direction of 30° or more, with a wind speed of 5 m s^{-1} (10 KT) or more before or after the change, or a change in wind speed of 5 m s^{-1} (10 KT) or more, lasting at least two minutes.

CODE TABLE: FM201 – COLLECT

There are no code tables that are specific to FM201.

CODE TABLE: FM202 – METCE

CODE TABLE D-3: METCE OBSERVATION TYPES

The items within this code table are specialized observation or measurement types defined within 'Modèle pour l'Échange des informations sur le Temps, le Climat et l'Eau' (METCE). Each observation or measurement type listed herein is specified as a class in METCE that derives from the OM_Observation class (defined in ISO 19156, Geographic information - Observations and measurements, clause 6.2) or sub-class thereof. A URI for each observation type is composed by appending the *notation* to the *code-space*. As an example, the URI of ComplexSamplingMeasurement is http://codes.wmo.int/common/observation-type/METCE/2013/ComplexSamplingMeasurement. The URI is also a URL providing additional information about the associated observation type. This code table is published at http://codes.wmo.int/common/observation-type/METCE/2013.

Label	Notation	Code-space	Description
Complex sampling measurement	ComplexSamplingMeasurement	http://codes.wmo.int/common/observation-type/METCE/2013/	ComplexSamplingMeasurement (a subclass of OM_ComplexObservation) is intended for use where the observation event is concerned with the evaluation of multiple measurands at a specified location and time instant or duration. The result of this observation type shall refer to an entity of metatype Record (from ISO 19103). ComplexSamplingMeasurement enforces the following additional constraints: 'featureOfInterest' shall refer to an entity of type SF_SpatialSamplingFeature (from ISO 19156), or subclass thereof; and 'procedure' shall refer to an entity of type Process (from METCE), or subclass thereof. The OM_ComplexObservation is used because the 'result' of this class of observations is a group of measures, provided as a record. Again, this matches the WMO application domain wherein multiple phenomena are measured within a single 'observation event'. The term ‘measurement’ is used in the name in an attempt to reduce confusion arising from the overloading of the term ‘observation’.

Label	Notation	Code-space	Description
Sampling coverage measurement	SamplingCoverageMeasurement	http://codes.wmo.int/common/observation-type/METCE/2013/	SamplingCoverageMeasurement (a subclass of OM_DiscreteCoverageObservation) is intended for use where the observation is concerned with the evaluation of measurands that vary with respect to space and/or time - the result of this observation type shall refer to an entity of type CV_DiscreteCoverage (from ISO 19123). ComplexSamplingMeasurement enforces the following additional constraints: 'featureOfInterest' shall refer to an entity of type SF_SpatialSamplingFeature (from ISO 19156), or subclass thereof; and 'procedure' shall refer to an entity of type Process (from METCE), or subclass thereof. The Class 'SamplingCoverageMeasurement' is based on the SamplingCoverageObservation which is defined in an informative annex of ISO 19156. The term 'measurement' is used in the name in an attempt to reduce confusion arising from the overloading of the term 'observation'.
Sampling observation	SamplingObservation	http://codes.wmo.int/common/observation-type/METCE/2013/	SamplingObservation (a subclass of OM_Observation) provides a general purpose observation type. It enforces the following additional constraints: 'featureOfInterest' shall refer to an entity of type SF_SpatialSamplingFeature (from ISO 19156), or subclass thereof; and 'procedure' shall refer to an entity of type Process (from METCE), or subclass thereof. SamplingObservation is intended for use where measurement of physical phenomena is not the goal of the procedure. For example, the procedure executed to define SIGMET reports results in the identification of areas of turbulence, icing or other meteorological phenomena.

CODE TABLE: FM203 – OPM

There are no code tables that are specific to FM203.

CODE TABLE: FM204 – SAF

There are no code tables that are specific to FM204.

CODE TABLE: FM205 – IWXXM

CODE TABLE D-4: IWXXM OBSERVATION TYPES

The items within this code table are specialized observation or measurement types defined within the ICAO Meteorological Information Exchange Model (IWXXM). Each observation or measurement type listed herein is specified as a class in IWXXM that derives from the OM_Observation class (defined in ISO 19156, Geographic information - Observations and measurements, clause 6.2) or sub-class thereof. A URI for each observation type is composed by appending the *notation* to the *code-space*. As an example, the URI of MeteorologicalAerodromeForecast is http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeForecast. The URI is also a URL providing additional information about the associated observation type. This code table is published at http://codes.wmo.int/49-2/observation-type/IWXXM/1.0.

Label	Notation	Code-space	Description
Meteorological aerodrome forecast	MeteorologicalAerodromeForecast	http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/	MeteorologicalAerodromeForecast (a subclass of ComplexSamplingMeasurement from METCE) is intended for use when reporting an aggregate set of forecast meteorological conditions at an aerodrome. The result of this observation type shall refer to an entity of type MeteorologicalAerodromeForecastRecord. MeteorologicalAerodromeForecast enforces the following additional constraints: 'featureOfInterest' shall refer to an entity of type SF_SamplingPoint and the associated 'sampledFeature' must be an Aerodrome. This class is also related but not identical to MeteorologicalAerodromeTrendForecast which is reported on a METAR/SPECI - conditions reported in trend forecasts in METAR/SPECI differ from forecast groups in a TAF. The TAF forecast group from/to variants (FM, TL, AT, etc.) are represented on the OM_Observation validTime, which is always an instance of TM_Period. When there is only an instant at which a condition occurs, the start and end time are the same.

Label	Notation	Code-space	Description
Meteorological aerodrome observation	MeteorologicalAerodromeObservation	http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/	MeteorologicalAerodromeObservation (a subclass of ComplexSamplingMeasurement from METCE) is intended for use when reporting an aggregate set of observed meteorological conditions at an aerodrome. The result of this observation type shall refer to an entity of type MeteorologicalAerodromeObservationRecord. MeteorologicalAerodromeObservation enforces the following additional constraints: 'featureOfInterest' shall refer to an entity of type SF_SamplingPoint and the associated 'sampledFeature' must be an Aerodrome. MeteorologicalAerodromeObservation has a peer class for forecast information at an aerodrome: MeteorologicalAerodromeTrendForecast.
Meteorological aerodrome trend forecast	MeteorologicalAerodromeTrendForecast	http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/	MeteorologicalAerodromeTrendForecast (a subclass of ComplexSamplingMeasurement from METCE) is intended for use when reporting an aggregate set of forecast meteorological conditions at an aerodrome. The result of this observation type shall refer to an entity of type MeteorologicalAerodromeTrendForecastRecord. MeteorologicalAerodromeTrendForecast enforces the following additional constraints: 'featureOfInterest' shall refer to an entity of type SF_SamplingPoint and the associated 'sampledFeature' must be an aerodrome. MeteorologicalAerodromeTrendForecasts are reported in surface observation reports such as SPECI and METAR. MeteorologicalAerodromeTrendForecast has a peer class for observation information at an aerodrome (MeteorologicalAerodromeObservation) which is also reported on a METAR and SPECI for observed phenomena. This class is also related but not identical to MeteorologicalAerodromeForecast which is reported on a TAF - conditions reported in trend forecasts in METAR/SPECI differ from forecast groups in a TAF.

Label	Notation	Code-space	Description
SIGMET evolving condition analysis	SIGMETEvolvingConditionAnalysis	http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/	SIGMETEvolvingConditionAnalysis (a subclass of SamplingObservation from METCE) is intended for use when reporting an observed or forecast aggregate set of meteorological conditions hazardous to flight over a large airspace, including anticipated intensity change plus speed and direction of motion. The result of this observation type shall refer to a single EvolvingMeteorologicalCondition which represents a SIGMET observation or forecast of meteorological conditions. SIGMETEvolvingConditionAnalysis enforces the following additional constraints: 'featureOfInterest' shall refer to an entity of type SF_SamplingSurface and the associated 'sampledFeature' must be an airspace.
SIMGET position analysis	SIGMETPositionAnalysis	http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/	SIGMETPositionAnalysis (a subclass of SamplingObservation from METCE) is intended for use when reporting the forecast position of meteorological conditions hazardous to flight. The result of this observation type shall refer to one or more MeteorologicalPositions which represents the forecast positions of SIGMET phenomena. SIGMETPositionAnalysis enforces the following additional constraints: 'featureOfInterest' shall refer to an entity of type SF_SamplingSurface and the associated 'sampledFeature' must be an airspace.

CODE TABLE D-4: IWXXM OBSERVABLE PROPERTIES

The items within this code table are composite observable properties that define the set of physical properties evaluated as a result of regulated procedures specified in Technical Regulations, Volume II (WMO-No. 49): Meteorological Services for International Air Navigation. These include aerodrome observation and forecast reports (e.g. METAR, SPECI and TAF). A URI for each observable property is composed by appending the *notation* to the *code-space*. As an example, the URI of MeteorologicalAerodromeForecast is http://codes.wmo.int/49-2/observable-property/MeteorologicalAerodromeForecast. The URI is also a URL providing additional information about the associated observable property. This code table is published at http://codes.wmo.int/49-2/observable-property.

Label	Notation	Code-space	Description
Meteorological aerodrome forecast	MeteorologicalAerodromeForecast	http://codes.wmo.int/49-2/observable-property/	The set of physical properties evaluated as a result of an aerodrome forecast (TAF), as specified in Technical Regulations, Volume II (WMO-No. 49): Meteorological Services for International Air Navigation.
Meteorological aerodrome observation	MeteorologicalAerodromeObservation	http://codes.wmo.int/49-2/observable-property/	The set of physical properties evaluated as a result of the observation procedure of a routine or special aerodrome meteorological report (METAR or SPECI), as specified in Technical Regulations, Volume II (WMO-No. 49): Meteorological Services for International Air Navigation.
Meteorological aerodrome trend forecast	MeteorologicalAerodromeTrendForecast	http://codes.wmo.int/49-2/observable-property/	The set of physical properties evaluated as a result of the trend forecast procedure of a routine or special aerodrome meteorological report (METAR or SPECI), as specified in Technical Regulations, Volume II (WMO-No. 49): Meteorological Services for International Air Navigation.

CODE TABLE D-5: AERODROME RECENT WEATHER

The items within this code table are the weather types that may be reported within a meteorological aerodrome observation report that have occurred during the period since the last issued routine report or last hour, whichever is shorter, but are not observed at the time of the observation. Requirements for reporting recent weather at an aerodrome are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.8.1.1.

This code table contains the set of weather types that are permitted for reporting recent weather. These are a subset of the enumerated set of meteorologically valid combinations specified in Part A, Code table 4678 comprising elements ‘intensity or proximity’, ‘descriptor’, ‘precipitation’, ‘obscuration’ and/or ‘other’.

Each weather type is uniquely identified using a URI. The URI is also a URL providing additional information about the associated weather type. This code table is published at http://codes.wmo.int/49-2/AerodromeRecentWeather.

Label	Notation	URI
Blowing snow	REBLSN	http://codes.wmo.int/306/4678/BLSN
Duststorm	REDS	http://codes.wmo.int/306/4678/DS
Precipitation of drizzle	REDZ	http://codes.wmo.int/306/4678/DZ
Funnel cloud(s) (tornado or water spout)	REFC	http://codes.wmo.int/306/4678/FC
Precipitation of freezing drizzle	REFZDZ	http://codes.wmo.int/306/4678/FZDZ
Precipitation of freezing rain	REFZRA	http://codes.wmo.int/306/4678/FZRA
Unidentified freezing precipitation	REFZUP	http://codes.wmo.int/306/4678/FZUP
Precipitation of ice pellets	REPL	http://codes.wmo.int/306/4678/PL
Precipitation of rain	RERA	http://codes.wmo.int/306/4678/RA
Precipitation of snow grains	RESG	http://codes.wmo.int/306/4678/SG
Showery precipitation of hail	RESHGR	http://codes.wmo.int/306/4678/SHGR
Showery precipitation of snow pellets/small hail	RESHGS	http://codes.wmo.int/306/4678/SHGS
Showery precipitation of rain	RESHRA	http://codes.wmo.int/306/4678/SHRA
Showery precipitation of snow	RESHSN	http://codes.wmo.int/306/4678/SHSN
Unidentified showery precipitation	RESHUP	http://codes.wmo.int/306/4678/SHUP
Precipitation of snow	RESN	http://codes.wmo.int/306/4678/SN
Sandstorm	RESS	http://codes.wmo.int/306/4678/SS
Thunderstorm	RETS	http://codes.wmo.int/306/4678/TS
Thunderstorm with precipitation of hail	RETSGR	http://codes.wmo.int/306/4678/TSGR
Thunderstorm with precipitation of snow pellets/small hail	RETSGS	http://codes.wmo.int/306/4678/TSGS
Thunderstorm with precipitation of rain	RETSRA	http://codes.wmo.int/306/4678/TSRA
Thunderstorm with precipitation of snow	RETSSN	http://codes.wmo.int/306/4678/TSSN
Thunderstorm with unidentified precipitation	RETSUP	http://codes.wmo.int/306/4678/TSUP
Unidentified precipitation	REUP	http://codes.wmo.int/306/4678/UP
Volcanic ash	REVA	http://codes.wmo.int/306/4678/VA

CODE TABLE D-6: AERODROME PRESENT OR FORECAST WEATHER

The items within this code table are the weather phenomena that may be reported as forecast to occur or have been observed at an aerodrome. Requirements for reporting present or forecast weather at an aerodrome are specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 3, [C.3.1.] 4.4 (observation), Appendix 5, [C.3.1] 2.2.4 (trend forecast) and [C.3.1.] 1.2.3 (for TAF).

The weather phenomena listed here are a subset of the enumerated set of meteorologically valid combinations specified in Part A, Code table 4678 comprising elements 'intensity or proximity', 'descriptor', 'precipitation', 'obscuration' and/or 'other'.

Each weather type is uniquely identified using a URI. The URI is also a URL providing additional information about the associated weather type. This code table is published at http://codes.wmo.int/49-2/AerodromePresentOrForecastWeather.

Label	Notation	URI
Light precipitation of drizzle	-DZ	http://codes.wmo.int/306/4678/-DZ
Light precipitation of rain	-RA	http://codes.wmo.int/306/4678/-RA
Light precipitation of snow	-SN	http://codes.wmo.int/306/4678/-SN
Light precipitation of snow grains	-SG	http://codes.wmo.int/306/4678/-SG
Light precipitation of ice pellets	-PL	http://codes.wmo.int/306/4678/-PL
Light unidentified precipitation	-UP	http://codes.wmo.int/306/4678/-UP
Light precipitation of drizzle and rain	-DZRA	http://codes.wmo.int/306/4678/-DZRA
Light precipitation of rain and drizzle	-RADZ	http://codes.wmo.int/306/4678/-RADZ
Light precipitation of snow and drizzle	-SNDZ	http://codes.wmo.int/306/4678/-SNDZ
Light precipitation of snow grains and drizzle	-SGDZ	http://codes.wmo.int/306/4678/-SGDZ
Light precipitation of ice pellets and drizzle	-PLDZ	http://codes.wmo.int/306/4678/-PLDZ
Light precipitation of drizzle and snow	-DZSN	http://codes.wmo.int/306/4678/-DZSN
Light precipitation of rain and snow	-RASN	http://codes.wmo.int/306/4678/-RASN
Light precipitation of snow and rain	-SNRA	http://codes.wmo.int/306/4678/-SNRA
Light precipitation of snow grains and rain	-SGRA	http://codes.wmo.int/306/4678/-SGRA
Light precipitation of ice pellets and rain	-PLRA	http://codes.wmo.int/306/4678/-PLRA
Light precipitation of drizzle and snow grains	-DZSG	http://codes.wmo.int/306/4678/-DZSG
Light precipitation of rain and snow grains	-RASG	http://codes.wmo.int/306/4678/-RASG
Light precipitation of snow and snow grains	-SNSG	http://codes.wmo.int/306/4678/-SNSG
Light precipitation of snow grains and snow	-SGSN	http://codes.wmo.int/306/4678/-SGSN
Light precipitation of ice pellets and snow	-PLSN	http://codes.wmo.int/306/4678/-PLSN
Light precipitation of drizzle and ice pellets	-DZPL	http://codes.wmo.int/306/4678/-DZPL
Light precipitation of rain and ice pellets	-RAPL	http://codes.wmo.int/306/4678/-RAPL

Label	Notation	URI
Light precipitation of snow and ice pellets	-SNPL	http://codes.wmo.int/306/4678/-SNPL
Light precipitation of snow grains and ice pellets	-SGPL	http://codes.wmo.int/306/4678/-SGPL
Light precipitation of ice pellets and snow grains	-PLSG	http://codes.wmo.int/306/4678/-PLSG
Light precipitation of drizzle, rain and snow	-DZRASN	http://codes.wmo.int/306/4678/-DZRASN
Light precipitation of drizzle, snow and rain	-DZSNRA	http://codes.wmo.int/306/4678/-DZSNRA
Light precipitation of rain, drizzle and snow	-RADZSN	http://codes.wmo.int/306/4678/-RADZSN
Light precipitation of rain, snow and drizzle	-RASNDZ	http://codes.wmo.int/306/4678/-RASNDZ
Light precipitation of snow, drizzle and rain	-SNDZRA	http://codes.wmo.int/306/4678/-SNDZRA
Light precipitation of snow, rain and drizzle	-SNRADZ	http://codes.wmo.int/306/4678/-SNRADZ
Light precipitation of drizzle, rain and snow grains	-DZRASG	http://codes.wmo.int/306/4678/-DZRASG
Light precipitation of drizzle, snow grains and rain	-DZSGRA	http://codes.wmo.int/306/4678/-DZSGRA
Light precipitation of rain, drizzle and snow grains	-RADZSG	http://codes.wmo.int/306/4678/-RADZSG
Light precipitation of rain, snow grains and drizzle	-RASGDZ	http://codes.wmo.int/306/4678/-RASGDZ
Light precipitation of snow grains, drizzle and rain	-SGDZRA	http://codes.wmo.int/306/4678/-SGDZRA
Light precipitation of snow grains, rain and drizzle	-SGRADZ	http://codes.wmo.int/306/4678/-SGRADZ
Light precipitation of drizzle, rain and ice pellets	-DZRAPL	http://codes.wmo.int/306/4678/-DZRAPL
Light precipitation of drizzle, ice pellets and rain	-DZPLRA	http://codes.wmo.int/306/4678/-DZPLRA
Light precipitation of rain, drizzle and ice pellets	-RADZPL	http://codes.wmo.int/306/4678/-RADZPL
Light precipitation of rain, ice pellets and drizzle	-RAPLDZ	http://codes.wmo.int/306/4678/-RAPLDZ
Light precipitation of ice pellets, drizzle and rain	-PLDZRA	http://codes.wmo.int/306/4678/-PLDZRA
Light precipitation of ice pellets, rain and drizzle	-PLRADZ	http://codes.wmo.int/306/4678/-PLRADZ
Light precipitation of rain, snow and snow grains	-RASNSG	http://codes.wmo.int/306/4678/-RASNSG
Light precipitation of rain, snow grains and snow	-RASGSN	http://codes.wmo.int/306/4678/-RASGSN
Light precipitation of snow, rain and snow grains	-SNRASG	http://codes.wmo.int/306/4678/-SNRASG
Light precipitation of snow, snow grains and rain	-SNSGRA	http://codes.wmo.int/306/4678/-SNSGRA
Light precipitation of snow grains, rain and snow	-SGRASN	http://codes.wmo.int/306/4678/-SGRASN
Light precipitation of snow grains, snow and rain	-SGSNRA	http://codes.wmo.int/306/4678/-SGSNRA
Light precipitation of rain, snow and ice pellets	-RASNPL	http://codes.wmo.int/306/4678/-RASNPL
Light precipitation of rain, ice pellets and snow	-RAPLSN	http://codes.wmo.int/306/4678/-RAPLSN
Light precipitation of snow, rain and ice pellets	-SNRAPL	http://codes.wmo.int/306/4678/-SNRAPL
Light precipitation of snow, ice pellets and rain	-SNPLRA	http://codes.wmo.int/306/4678/-SNPLRA
Light precipitation of ice pellets, rain and snow	-PLRASN	http://codes.wmo.int/306/4678/-PLRASN
Light precipitation of ice pellets, snow and rain	-PLSNRA	http://codes.wmo.int/306/4678/-PLSNRA

Label	Notation	URI
Light precipitation of ice pellets, snow and snow grains	-PLSNSG	http://codes.wmo.int/306/4678/-PLSNSG
Light precipitation of ice pellets, snow grains and snow	-PLSGSN	http://codes.wmo.int/306/4678/-PLSGSN
Light precipitation of snow, ice pellets and snow grains	-SNPLSG	http://codes.wmo.int/306/4678/-SNPLSG
Light precipitation of snow, snow grains and ice pellets	-SNSGPL	http://codes.wmo.int/306/4678/-SNSGPL
Light precipitation of snow grains, ice pellets and snow	-SGPLSN	http://codes.wmo.int/306/4678/-SGPLSN
Light precipitation of snow grains, snow and ice pellets	-SGSNPL	http://codes.wmo.int/306/4678/-SGSNPL
Precipitation of drizzle	DZ	http://codes.wmo.int/306/4678/DZ
Precipitation of rain	RA	http://codes.wmo.int/306/4678/RA
Precipitation of snow	SN	http://codes.wmo.int/306/4678/SN
Precipitation of snow grains	SG	http://codes.wmo.int/306/4678/SG
Precipitation of ice pellets	PL	http://codes.wmo.int/306/4678/PL
Unidentified precipitation	UP	http://codes.wmo.int/306/4678/UP
Precipitation of drizzle and rain	DZRA	http://codes.wmo.int/306/4678/DZRA
Precipitation of rain and drizzle	RADZ	http://codes.wmo.int/306/4678/RADZ
Precipitation of snow and drizzle	SNDZ	http://codes.wmo.int/306/4678/SNDZ
Precipitation of snow grains and drizzle	SGDZ	http://codes.wmo.int/306/4678/SGDZ
Precipitation of ice pellets and drizzle	PLDZ	http://codes.wmo.int/306/4678/PLDZ
Precipitation of drizzle and snow	DZSN	http://codes.wmo.int/306/4678/DZSN
Precipitation of rain and snow	RASN	http://codes.wmo.int/306/4678/RASN
Precipitation of snow and rain	SNRA	http://codes.wmo.int/306/4678/SNRA
Precipitation of snow grains and rain	SGRA	http://codes.wmo.int/306/4678/SGRA
Precipitation of ice pellets and rain	PLRA	http://codes.wmo.int/306/4678/PLRA
Precipitation of drizzle and snow grains	DZSG	http://codes.wmo.int/306/4678/DZSG
Precipitation of rain and snow grains	RASG	http://codes.wmo.int/306/4678/RASG
Precipitation of snow and snow grains	SNSG	http://codes.wmo.int/306/4678/SNSG
Precipitation of snow grains and snow	SGSN	http://codes.wmo.int/306/4678/SGSN
Precipitation of ice pellets and snow	PLSN	http://codes.wmo.int/306/4678/PLSN
Precipitation of drizzle and ice pellets	DZPL	http://codes.wmo.int/306/4678/DZPL
Precipitation of rain and ice pellets	RAPL	http://codes.wmo.int/306/4678/RAPL
Precipitation of snow and ice pellets	SNPL	http://codes.wmo.int/306/4678/SNPL

Label	Notation	URI
Precipitation of snow grains and ice pellets	SGPL	http://codes.wmo.int/306/4678/SGPL
Precipitation of ice pellets and snow grains	PLSG	http://codes.wmo.int/306/4678/PLSG
Precipitation of drizzle, rain and snow	DZRASN	http://codes.wmo.int/306/4678/DZRASN
Precipitation of drizzle, snow and rain	DZSNRA	http://codes.wmo.int/306/4678/DZSNRA
Precipitation of rain, drizzle and snow	RADZSN	http://codes.wmo.int/306/4678/RADZSN
Precipitation of rain, snow and drizzle	RASNDZ	http://codes.wmo.int/306/4678/RASNDZ
Precipitation of snow, drizzle and rain	SNDZRA	http://codes.wmo.int/306/4678/SNDZRA
Precipitation of snow, rain and drizzle	SNRADZ	http://codes.wmo.int/306/4678/SNRADZ
Precipitation of drizzle, rain and snow grains	DZRASG	http://codes.wmo.int/306/4678/DZRASG
Precipitation of drizzle, snow grains and rain	DZSGRA	http://codes.wmo.int/306/4678/DZSGRA
Precipitation of rain, drizzle and snow grains	RADZSG	http://codes.wmo.int/306/4678/RADZSG
Precipitation of rain, snow grains and drizzle	RASGDZ	http://codes.wmo.int/306/4678/RASGDZ
Precipitation of snow grains, drizzle and rain	SGDZRA	http://codes.wmo.int/306/4678/SGDZRA
Precipitation of snow grains, rain and drizzle	SGRADZ	http://codes.wmo.int/306/4678/SGRADZ
Precipitation of drizzle, rain and ice pellets	DZRAPL	http://codes.wmo.int/306/4678/DZRAPL
Precipitation of drizzle, ice pellets and rain	DZPLRA	http://codes.wmo.int/306/4678/DZPLRA
Precipitation of rain, drizzle and ice pellets	RADZPL	http://codes.wmo.int/306/4678/RADZPL
Precipitation of rain, ice pellets and drizzle	RAPLDZ	http://codes.wmo.int/306/4678/RAPLDZ
Precipitation of ice pellets, drizzle and rain	PLDZRA	http://codes.wmo.int/306/4678/PLDZRA
Precipitation of ice pellets, rain and drizzle	PLRADZ	http://codes.wmo.int/306/4678/PLRADZ
Precipitation of rain, snow and snow grains	RASNSG	http://codes.wmo.int/306/4678/RASNSG
Precipitation of rain, snow grains and snow	RASGSN	http://codes.wmo.int/306/4678/RASGSN
Precipitation of snow, rain and snow grains	SNRASG	http://codes.wmo.int/306/4678/SNRASG
Precipitation of snow, snow grains and rain	SNSGRA	http://codes.wmo.int/306/4678/SNSGRA
Precipitation of snow grains, rain and snow	SGRASN	http://codes.wmo.int/306/4678/SGRASN
Precipitation of snow grains, snow and rain	SGSNRA	http://codes.wmo.int/306/4678/SGSNRA
Precipitation of rain, snow and ice pellets	RASNPL	http://codes.wmo.int/306/4678/RASNPL
Precipitation of rain, ice pellets and snow	RAPLSN	http://codes.wmo.int/306/4678/RAPLSN
Precipitation of snow, rain and ice pellets	SNRAPL	http://codes.wmo.int/306/4678/SNRAPL
Precipitation of snow, ice pellets and rain	SNPLRA	http://codes.wmo.int/306/4678/SNPLRA
Precipitation of ice pellets, rain and snow	PLRASN	http://codes.wmo.int/306/4678/PLRASN
Precipitation of ice pellets, snow and rain	PLSNRA	http://codes.wmo.int/306/4678/PLSNRA
Precipitation of ice pellets, snow and snow grains	PLSNSG	http://codes.wmo.int/306/4678/PLSNSG

Label	Notation	URI
Precipitation of ice pellets, snow grains and snow	PLSGSN	http://codes.wmo.int/306/4678/PLSGSN
Precipitation of snow, ice pellets and snow grains	SNPLSG	http://codes.wmo.int/306/4678/SNPLSG
Precipitation of snow, snow grains and ice pellets	SNSGPL	http://codes.wmo.int/306/4678/SNSGPL
Precipitation of snow grains, ice pellets and snow	SGPLSN	http://codes.wmo.int/306/4678/SGPLSN
Precipitation of snow grains, snow and ice pellets	SGSNPL	http://codes.wmo.int/306/4678/SGSNPL
Heavy precipitation of drizzle	+DZ	http://codes.wmo.int/306/4678/+DZ
Heavy precipitation of rain	+RA	http://codes.wmo.int/306/4678/+RA
Heavy precipitation of snow	+SN	http://codes.wmo.int/306/4678/+SN
Heavy precipitation of snow grains	+SG	http://codes.wmo.int/306/4678/+SG
Heavy precipitation of ice pellets	+PL	http://codes.wmo.int/306/4678/+PL
Heavy unidentified precipitation	+UP	http://codes.wmo.int/306/4678/+UP
Heavy precipitation of drizzle and rain	+DZRA	http://codes.wmo.int/306/4678/+DZRA
Heavy precipitation of rain and drizzle	+RADZ	http://codes.wmo.int/306/4678/+RADZ
Heavy precipitation of snow and drizzle	+SNDZ	http://codes.wmo.int/306/4678/+SNDZ
Heavy precipitation of snow grains and drizzle	+SGDZ	http://codes.wmo.int/306/4678/+SGDZ
Heavy precipitation of ice pellets and drizzle	+PLDZ	http://codes.wmo.int/306/4678/+PLDZ
Heavy precipitation of drizzle and snow	+DZSN	http://codes.wmo.int/306/4678/+DZSN
Heavy precipitation of rain and snow	+RASN	http://codes.wmo.int/306/4678/+RASN
Heavy precipitation of snow and rain	+SNRA	http://codes.wmo.int/306/4678/+SNRA
Heavy precipitation of snow grains and rain	+SGRA	http://codes.wmo.int/306/4678/+SGRA
Heavy precipitation of ice pellets and rain	+PLRA	http://codes.wmo.int/306/4678/+PLRA
Heavy precipitation of drizzle and snow grains	+DZSG	http://codes.wmo.int/306/4678/+DZSG
Heavy precipitation of rain and snow grains	+RASG	http://codes.wmo.int/306/4678/+RASG
Heavy precipitation of snow and snow grains	+SNSG	http://codes.wmo.int/306/4678/+SNSG
Heavy precipitation of snow grains and snow	+SGSN	http://codes.wmo.int/306/4678/+SGSN
Heavy precipitation of ice pellets and snow	+PLSN	http://codes.wmo.int/306/4678/+PLSN
Heavy precipitation of drizzle and ice pellets	+DZPL	http://codes.wmo.int/306/4678/+DZPL
Heavy precipitation of rain and ice pellets	+RAPL	http://codes.wmo.int/306/4678/+RAPL
Heavy precipitation of snow and ice pellets	+SNPL	http://codes.wmo.int/306/4678/+SNPL
Heavy precipitation of snow grains and ice pellets	+SGPL	http://codes.wmo.int/306/4678/+SGPL
Heavy precipitation of ice pellets and snow grains	+PLSG	http://codes.wmo.int/306/4678/+PLSG
Heavy precipitation of drizzle, rain and snow	+DZRASN	http://codes.wmo.int/306/4678/+DZRASN
Heavy precipitation of drizzle, snow and rain	+DZSNRA	http://codes.wmo.int/306/4678/+DZSNRA

Label	Notation	URI
Heavy precipitation of rain, drizzle and snow	+RADZSN	http://codes.wmo.int/306/4678/+RADZSN
Heavy precipitation of rain, snow and drizzle	+RASNDZ	http://codes.wmo.int/306/4678/+RASNDZ
Heavy precipitation of snow, drizzle and rain	+SNDZRA	http://codes.wmo.int/306/4678/+SNDZRA
Heavy precipitation of snow, rain and drizzle	+SNRADZ	http://codes.wmo.int/306/4678/+SNRADZ
Heavy precipitation of drizzle, rain and snow grains	+DZRASG	http://codes.wmo.int/306/4678/+DZRASG
Heavy precipitation of drizzle, snow grains and rain	+DZSGRA	http://codes.wmo.int/306/4678/+DZSGRA
Heavy precipitation of rain, drizzle and snow grains	+RADZSG	http://codes.wmo.int/306/4678/+RADZSG
Heavy precipitation of rain, snow grains and drizzle	+RASGDZ	http://codes.wmo.int/306/4678/+RASGDZ
Heavy precipitation of snow grains, drizzle and rain	+SGDZRA	http://codes.wmo.int/306/4678/+SGDZRA
Heavy precipitation of snow grains, rain and drizzle	+SGRADZ	http://codes.wmo.int/306/4678/+SGRADZ
Heavy precipitation of drizzle, rain and ice pellets	+DZRAPL	http://codes.wmo.int/306/4678/+DZRAPL
Heavy precipitation of drizzle, ice pellets and rain	+DZPLRA	http://codes.wmo.int/306/4678/+DZPLRA
Heavy precipitation of rain, drizzle and ice pellets	+RADZPL	http://codes.wmo.int/306/4678/+RADZPL
Heavy precipitation of rain, ice pellets and drizzle	+RAPLDZ	http://codes.wmo.int/306/4678/+RAPLDZ
Heavy precipitation of ice pellets, drizzle and rain	+PLDZRA	http://codes.wmo.int/306/4678/+PLDZRA
Heavy precipitation of ice pellets, rain and drizzle	+PLRADZ	http://codes.wmo.int/306/4678/+PLRADZ
Heavy precipitation of rain, snow and snow grains	+RASNSG	http://codes.wmo.int/306/4678/+RASNSG
Heavy precipitation of rain, snow grains and snow	+RASGSN	http://codes.wmo.int/306/4678/+RASGSN
Heavy precipitation of snow, rain and snow grains	+SNRASG	http://codes.wmo.int/306/4678/+SNRASG
Heavy precipitation of snow, snow grains and rain	+SNSGRA	http://codes.wmo.int/306/4678/+SNSGRA
Heavy precipitation of snow grains, rain and snow	+SGRASN	http://codes.wmo.int/306/4678/+SGRASN
Heavy precipitation of snow grains, snow and rain	+SGSNRA	http://codes.wmo.int/306/4678/+SGSNRA
Heavy precipitation of rain, snow and ice pellets	+RASNPL	http://codes.wmo.int/306/4678/+RASNPL
Heavy precipitation of rain, ice pellets and snow	+RAPLSN	http://codes.wmo.int/306/4678/+RAPLSN
Heavy precipitation of snow, rain and ice pellets	+SNRAPL	http://codes.wmo.int/306/4678/+SNRAPL
Heavy precipitation of snow, ice pellets and rain	+SNPLRA	http://codes.wmo.int/306/4678/+SNPLRA
Heavy precipitation of ice pellets, rain and snow	+PLRASN	http://codes.wmo.int/306/4678/+PLRASN
Heavy precipitation of ice pellets, snow and rain	+PLSNRA	http://codes.wmo.int/306/4678/+PLSNRA
Heavy precipitation of ice pellets, snow and snow grains	+PLSNSG	http://codes.wmo.int/306/4678/+PLSNSG
Heavy precipitation of ice pellets, snow grains and snow	+PLSGSN	http://codes.wmo.int/306/4678/+PLSGSN
Heavy precipitation of snow, ice pellets and snow grains	+SNPLSG	http://codes.wmo.int/306/4678/+SNPLSG

Label	Notation	URI
Heavy precipitation of snow, snow grains and ice pellets	+SNSGPL	http://codes.wmo.int/306/4678/+SNSGPL
Heavy precipitation of snow grains, ice pellets and snow	+SGPLSN	http://codes.wmo.int/306/4678/+SGPLSN
Heavy precipitation of snow grains, snow and ice pellets	+SGSNPL	http://codes.wmo.int/306/4678/+SGSNPL
Light showery precipitation of rain	-SHRA	http://codes.wmo.int/306/4678/-SHRA
Light showery precipitation of snow	-SHSN	http://codes.wmo.int/306/4678/-SHSN
Light showery precipitation of hail	-SHGR	http://codes.wmo.int/306/4678/-SHGR
Light showery precipitation of snow pellets/small hail	-SHGS	http://codes.wmo.int/306/4678/-SHGS
Light unidentified showery precipitation	-SHUP	http://codes.wmo.int/306/4678/-SHUP
Light showery precipitation of rain and snow	-SHRASN	http://codes.wmo.int/306/4678/-SHRASN
Light showery precipitation of snow and rain	-SHSNRA	http://codes.wmo.int/306/4678/-SHSNRA
Light showery precipitation of hail and rain	-SHGRRA	http://codes.wmo.int/306/4678/-SHGRRA
Light showery precipitation of snow pellets/small hail and rain	-SHGSRA	http://codes.wmo.int/306/4678/-SHGSRA
Light showery precipitation of rain and hail	-SHRAGR	http://codes.wmo.int/306/4678/-SHRAGR
Light showery precipitation of snow and hail	-SHSNGR	http://codes.wmo.int/306/4678/-SHSNGR
Light showery precipitation of hail and snow	-SHGRSN	http://codes.wmo.int/306/4678/-SHGRSN
Light showery precipitation of snow pellets/small hail and snow	-SHGSSN	http://codes.wmo.int/306/4678/-SHGSSN
Light showery precipitation of rain and snow pellets/small hail	-SHRAGS	http://codes.wmo.int/306/4678/-SHRAGS
Light showery precipitation of snow and snow pellets/small hail	-SHSNGS	http://codes.wmo.int/306/4678/-SHSNGS
Light showery precipitation of rain, snow and hail	-SHRASNGR	http://codes.wmo.int/306/4678/-SHRASNGR
Light showery precipitation of rain, hail and snow	-SHRAGRSN	http://codes.wmo.int/306/4678/-SHRAGRSN
Light showery precipitation of snow, rain and hail	-SHSNRAGR	http://codes.wmo.int/306/4678/-SHSNRAGR
Light showery precipitation of snow, hail and rain	-SHSNGRRA	http://codes.wmo.int/306/4678/-SHSNGRRA
Light showery precipitation of hail, rain and snow	-SHGRRASN	http://codes.wmo.int/306/4678/-SHGRRASN
Light showery precipitation of hail, snow and rain	-SHGRSNRA	http://codes.wmo.int/306/4678/-SHGRSNRA
Light showery precipitation of rain, snow and snow pellets/small hail	-SHRASNGS	http://codes.wmo.int/306/4678/-SHRASNGS
Light showery precipitation of rain, snow pellets/small hail and snow	-SHRAGSSN	http://codes.wmo.int/306/4678/-SHRAGSSN
Light showery precipitation of snow, rain and snow pellets/small hail	-SHSNRAGS	http://codes.wmo.int/306/4678/-SHSNRAGS
Light showery precipitation of snow, snow pellets/small hail and rain	-SHSNGSRA	http://codes.wmo.int/306/4678/-SHSNGSRA

Label	Notation	URI
Light showery precipitation of snow pellets/small hail, rain and snow	-SHGSRASN	http://codes.wmo.int/306/4678/-SHGSRASN
Light showery precipitation of snow pellets/small hail, snow and rain	-SHGSSNRA	http://codes.wmo.int/306/4678/-SHGSSNRA
Showery precipitation of rain	SHRA	http://codes.wmo.int/306/4678/SHRA
Showery precipitation of snow	SHSN	http://codes.wmo.int/306/4678/SHSN
Showery precipitation of hail	SHGR	http://codes.wmo.int/306/4678/SHGR
Showery precipitation of snow pellets/small hail	SHGS	http://codes.wmo.int/306/4678/SHGS
Unidentified showery precipitation	SHUP	http://codes.wmo.int/306/4678/SHUP
Showery precipitation of rain and snow	SHRASN	http://codes.wmo.int/306/4678/SHRASN
Showery precipitation of snow and rain	SHSNRA	http://codes.wmo.int/306/4678/SHSNRA
Showery precipitation of hail and rain	SHGRRA	http://codes.wmo.int/306/4678/SHGRRA
Showery precipitation of snow pellets/small hail and rain	SHGSRA	http://codes.wmo.int/306/4678/SHGSRA
Showery precipitation of rain and hail	SHRAGR	http://codes.wmo.int/306/4678/SHRAGR
Showery precipitation of snow and hail	SHSNGR	http://codes.wmo.int/306/4678/SHSNGR
Showery precipitation of hail and snow	SHGRSN	http://codes.wmo.int/306/4678/SHGRSN
Showery precipitation of snow pellets/small hail and snow	SHGSSN	http://codes.wmo.int/306/4678/SHGSSN
Showery precipitation of rain and snow pellets/small hail	SHRAGS	http://codes.wmo.int/306/4678/SHRAGS
Showery precipitation of snow and snow pellets/small hail	SHSNGS	http://codes.wmo.int/306/4678/SHSNGS
Showery precipitation of rain, snow and hail	SHRASNGR	http://codes.wmo.int/306/4678/SHRASNGR
Showery precipitation of rain, hail and snow	SHRAGRSN	http://codes.wmo.int/306/4678/SHRAGRSN
Showery precipitation of snow, rain and hail	SHSNRAGR	http://codes.wmo.int/306/4678/SHSNRAGR
Showery precipitation of snow, hail and rain	SHSNGRRA	http://codes.wmo.int/306/4678/SHSNGRRA
Showery precipitation of hail, rain and snow	SHGRRASN	http://codes.wmo.int/306/4678/SHGRRASN
Showery precipitation of hail, snow and rain	SHGRSNRA	http://codes.wmo.int/306/4678/SHGRSNRA
Showery precipitation of rain, snow and snow pellets/small hail	SHRASNGS	http://codes.wmo.int/306/4678/SHRASNGS
Showery precipitation of rain, snow pellets/small hail and snow	SHRAGSSN	http://codes.wmo.int/306/4678/SHRAGSSN
Showery precipitation of snow, rain and snow pellets/small hail	SHSNRAGS	http://codes.wmo.int/306/4678/SHSNRAGS
Showery precipitation of snow, snow pellets/small hail and rain	SHSNGSRA	http://codes.wmo.int/306/4678/SHSNGSRA
Showery precipitation of snow pellets/small hail, rain and snow	SHGSRASN	http://codes.wmo.int/306/4678/SHGSRASN

Label	Notation	URI
Showery precipitation of snow pellets/small hail, snow and rain	SHGSSNRA	http://codes.wmo.int/306/4678/SHGSSNRA
Heavy showery precipitation of rain	+SHRA	http://codes.wmo.int/306/4678/+SHRA
Heavy showery precipitation of snow	+SHSN	http://codes.wmo.int/306/4678/+SHSN
Heavy showery precipitation of hail	+SHGR	http://codes.wmo.int/306/4678/+SHGR
Heavy showery precipitation of snow pellets/small hail	+SHGS	http://codes.wmo.int/306/4678/+SHGS
Heavy unidentified showery precipitation	+SHUP	http://codes.wmo.int/306/4678/+SHUP
Heavy showery precipitation of rain and snow	+SHRASN	http://codes.wmo.int/306/4678/+SHRASN
Heavy showery precipitation of snow and rain	+SHSNRA	http://codes.wmo.int/306/4678/+SHSNRA
Heavy showery precipitation of hail and rain	+SHGRRA	http://codes.wmo.int/306/4678/+SHGRRA
Heavy showery precipitation of snow pellets/small hail and rain	+SHGSRA	http://codes.wmo.int/306/4678/+SHGSRA
Heavy showery precipitation of rain and hail	+SHRAGR	http://codes.wmo.int/306/4678/+SHRAGR
Heavy showery precipitation of snow and hail	+SHSNGR	http://codes.wmo.int/306/4678/+SHSNGR
Heavy showery precipitation of hail and snow	+SHGRSN	http://codes.wmo.int/306/4678/+SHGRSN
Heavy showery precipitation of snow pellets/small hail and snow	+SHGSSN	http://codes.wmo.int/306/4678/+SHGSSN
Heavy showery precipitation of rain and snow pellets/small hail	+SHRAGS	http://codes.wmo.int/306/4678/+SHRAGS
Heavy showery precipitation of snow and snow pellets/small hail	+SHSNGS	http://codes.wmo.int/306/4678/+SHSNGS
Heavy showery precipitation of rain, snow and hail	+SHRASNGR	http://codes.wmo.int/306/4678/+SHRASNGR
Heavy showery precipitation of rain, hail and snow	+SHRAGRSN	http://codes.wmo.int/306/4678/+SHRAGRSN
Heavy showery precipitation of snow, rain and hail	+SHSNRAGR	http://codes.wmo.int/306/4678/+SHSNRAGR
Heavy showery precipitation of snow, hail and rain	+SHSNGRRA	http://codes.wmo.int/306/4678/+SHSNGRRA
Heavy showery precipitation of hail, rain and snow	+SHGRRASN	http://codes.wmo.int/306/4678/+SHGRRASN
Heavy showery precipitation of hail, snow and rain	+SHGRSNRA	http://codes.wmo.int/306/4678/+SHGRSNRA
Heavy showery precipitation of rain, snow and snow pellets/small hail	+SHRASNGS	http://codes.wmo.int/306/4678/+SHRASNGS
Heavy showery precipitation of rain, snow pellets/small hail and snow	+SHRAGSSN	http://codes.wmo.int/306/4678/+SHRAGSSN
Heavy showery precipitation of snow, rain and snow pellets/small hail	+SHSNRAGS	http://codes.wmo.int/306/4678/+SHSNRAGS
Heavy showery precipitation of snow, snow pellets/small hail and rain	+SHSNGSRA	http://codes.wmo.int/306/4678/+SHSNGSRA
Heavy showery precipitation of snow pellets/small hail, rain and snow	+SHGSRASN	http://codes.wmo.int/306/4678/+SHGSRASN

Label	Notation	URI
Heavy showery precipitation of snow pellets/small hail, snow and rain	+SHGSSNRA	http://codes.wmo.int/306/4678/+SHGSSNRA
Thunderstorm with light precipitation of rain	-TSRA	http://codes.wmo.int/306/4678/-TSRA
Thunderstorm with light precipitation of snow	-TSSN	http://codes.wmo.int/306/4678/-TSSN
Thunderstorm with light precipitation of hail	-TSGR	http://codes.wmo.int/306/4678/-TSGR
Thunderstorm with light precipitation of snow pellets/small hail	-TSGS	http://codes.wmo.int/306/4678/-TSGS
Thunderstorm with light unidentified precipitation	-TSUP	http://codes.wmo.int/306/4678/-TSUP
Thunderstorm with light precipitation of rain and snow	-TSRASN	http://codes.wmo.int/306/4678/-TSRASN
Thunderstorm with light precipitation of snow and rain	-TSSNRA	http://codes.wmo.int/306/4678/-TSSNRA
Thunderstorm with light precipitation of hail and rain	-TSGRRA	http://codes.wmo.int/306/4678/-TSGRRA
Thunderstorm with light precipitation of snow pellets/small hail and rain	-TSGSRA	http://codes.wmo.int/306/4678/-TSGSRA
Thunderstorm with light precipitation of rain and hail	-TSRAGR	http://codes.wmo.int/306/4678/-TSRAGR
Thunderstorm with light precipitation of snow and hail	-TSSNGR	http://codes.wmo.int/306/4678/-TSSNGR
Thunderstorm with light precipitation of hail and snow	-TSGRSN	http://codes.wmo.int/306/4678/-TSGRSN
Thunderstorm with light precipitation of snow pellets/small hail and snow	-TSGSSN	http://codes.wmo.int/306/4678/-TSGSSN
Thunderstorm with light precipitation of rain and snow pellets/small hail	-TSRAGS	http://codes.wmo.int/306/4678/-TSRAGS
Thunderstorm with light precipitation of snow and snow pellets/small hail	-TSSNGS	http://codes.wmo.int/306/4678/-TSSNGS
Thunderstorm with light precipitation of rain, snow and hail	-TSRASNGR	http://codes.wmo.int/306/4678/-TSRASNGR
Thunderstorm with light precipitation of rain, hail and snow	-TSRAGRSN	http://codes.wmo.int/306/4678/-TSRAGRSN
Thunderstorm with light precipitation of snow, rain and hail	-TSSNRAGR	http://codes.wmo.int/306/4678/-TSSNRAGR
Thunderstorm with light precipitation of snow, hail and rain	-TSSNGRRA	http://codes.wmo.int/306/4678/-TSSNGRRA
Thunderstorm with light precipitation of hail, rain and snow	-TSGRRASN	http://codes.wmo.int/306/4678/-TSGRRASN
Thunderstorm with light precipitation of hail, snow and rain	-TSGRSNRA	http://codes.wmo.int/306/4678/-TSGRSNRA
Thunderstorm with light precipitation of rain, snow and snow pellets/small hail	-TSRASNGS	http://codes.wmo.int/306/4678/-TSRASNGS
Thunderstorm with light precipitation of rain, snow pellets/small hail and snow	-TSRAGSSN	http://codes.wmo.int/306/4678/-TSRAGSSN

Label	Notation	URI
Thunderstorm with light precipitation of snow, rain and snow pellets/small hail	-TSSNRAGS	http://codes.wmo.int/306/4678/-TSSNRAGS
Thunderstorm with light precipitation of snow, snow pellets/small hail and rain	-TSSNGSRA	http://codes.wmo.int/306/4678/-TSSNGSRA
Thunderstorm with light precipitation of snow pellets/small hail, rain and snow	-TSGSRASN	http://codes.wmo.int/306/4678/-TSGSRASN
Thunderstorm with light precipitation of snow pellets/small hail, snow and rain	-TSGSSNRA	http://codes.wmo.int/306/4678/-TSGSSNRA
Thunderstorm with precipitation of rain	TSRA	http://codes.wmo.int/306/4678/TSRA
Thunderstorm with precipitation of snow	TSSN	http://codes.wmo.int/306/4678/TSSN
Thunderstorm with precipitation of hail	TSGR	http://codes.wmo.int/306/4678/TSGR
Thunderstorm with precipitation of snow pellets/small hail	TSGS	http://codes.wmo.int/306/4678/TSGS
Thunderstorm with unidentified precipitation	TSUP	http://codes.wmo.int/306/4678/TSUP
Thunderstorm with precipitation of rain and snow	TSRASN	http://codes.wmo.int/306/4678/TSRASN
Thunderstorm with precipitation of snow and rain	TSSNRA	http://codes.wmo.int/306/4678/TSSNRA
Thunderstorm with precipitation of hail and rain	TSGRRA	http://codes.wmo.int/306/4678/TSGRRA
Thunderstorm with precipitation of snow pellets/small hail and rain	TSGSRA	http://codes.wmo.int/306/4678/TSGSRA
Thunderstorm with precipitation of rain and hail	TSRAGR	http://codes.wmo.int/306/4678/TSRAGR
Thunderstorm with precipitation of snow and hail	TSSNGR	http://codes.wmo.int/306/4678/TSSNGR
Thunderstorm with precipitation of hail and snow	TSGRSN	http://codes.wmo.int/306/4678/TSGRSN
Thunderstorm with precipitation of snow pellets/small hail and snow	TSGSSN	http://codes.wmo.int/306/4678/TSGSSN
Thunderstorm with precipitation of rain and snow pellets/small hail	TSRAGS	http://codes.wmo.int/306/4678/TSRAGS
Thunderstorm with precipitation of snow and snow pellets/small hail	TSSNGS	http://codes.wmo.int/306/4678/TSSNGS
Thunderstorm with precipitation of rain, snow and hail	TSRASNGR	http://codes.wmo.int/306/4678/TSRASNGR
Thunderstorm with precipitation of rain, hail and snow	TSRAGRSN	http://codes.wmo.int/306/4678/TSRAGRSN
Thunderstorm with precipitation of snow, rain and hail	TSSNRAGR	http://codes.wmo.int/306/4678/TSSNRAGR
Thunderstorm with precipitation of snow, hail and rain	TSSNGRRA	http://codes.wmo.int/306/4678/TSSNGRRA
Thunderstorm with precipitation of hail, rain and snow	TSGRRASN	http://codes.wmo.int/306/4678/TSGRRASN
Thunderstorm with precipitation of hail, snow and rain	TSGRSNRA	http://codes.wmo.int/306/4678/TSGRSNRA

Label	Notation	URI
Thunderstorm with precipitation of rain, snow and snow pellets/small hail	TSRASNGS	http://codes.wmo.int/306/4678/TSRASNGS
Thunderstorm with precipitation of rain, snow pellets/small hail and snow	TSRAGSSN	http://codes.wmo.int/306/4678/TSRAGSSN
Thunderstorm with precipitation of snow, rain and snow pellets/small hail	TSSNRAGS	http://codes.wmo.int/306/4678/TSSNRAGS
Thunderstorm with precipitation of snow, snow pellets/small hail and rain	TSSNGSRA	http://codes.wmo.int/306/4678/TSSNGSRA
Thunderstorm with precipitation of snow pellets/small hail, rain and snow	TSGSRASN	http://codes.wmo.int/306/4678/TSGSRASN
Thunderstorm with precipitation of snow pellets/small hail, snow and rain	TSGSSNRA	http://codes.wmo.int/306/4678/TSGSSNRA
Thunderstorm with heavy precipitation of rain	+TSRA	http://codes.wmo.int/306/4678/+TSRA
Thunderstorm with heavy precipitation of snow	+TSSN	http://codes.wmo.int/306/4678/+TSSN
Thunderstorm with heavy precipitation of hail	+TSGR	http://codes.wmo.int/306/4678/+TSGR
Thunderstorm with heavy precipitation of snow pellets/small hail	+TSGS	http://codes.wmo.int/306/4678/+TSGS
Thunderstorm with heavy precipitation of unidentified precipitation	+TSUP	http://codes.wmo.int/306/4678/+TSUP
Thunderstorm with heavy precipitation of rain and snow	+TSRASN	http://codes.wmo.int/306/4678/+TSRASN
Thunderstorm with heavy precipitation of snow and rain	+TSSNRA	http://codes.wmo.int/306/4678/+TSSNRA
Thunderstorm with heavy precipitation of hail and rain	+TSGRRA	http://codes.wmo.int/306/4678/+TSGRRA
Thunderstorm with heavy precipitation of snow pellets/small hail and rain	+TSGSRA	http://codes.wmo.int/306/4678/+TSGSRA
Thunderstorm with heavy precipitation of rain and hail	+TSRAGR	http://codes.wmo.int/306/4678/+TSRAGR
Thunderstorm with heavy precipitation of snow and hail	+TSSNGR	http://codes.wmo.int/306/4678/+TSSNGR
Thunderstorm with heavy precipitation of hail and snow	+TSGRSN	http://codes.wmo.int/306/4678/+TSGRSN
Thunderstorm with heavy precipitation of snow pellets/small hail and snow	+TSGSSN	http://codes.wmo.int/306/4678/+TSGSSN
Thunderstorm with heavy precipitation of rain and snow pellets/small hail	+TSRAGS	http://codes.wmo.int/306/4678/+TSRAGS
Thunderstorm with heavy precipitation of snow and snow pellets/small hail	+TSSNGS	http://codes.wmo.int/306/4678/+TSSNGS
Thunderstorm with heavy precipitation of rain, snow and hail	+TSRASNGR	http://codes.wmo.int/306/4678/+TSRASNGR
Thunderstorm with heavy precipitation of rain, hail and snow	+TSRAGRSN	http://codes.wmo.int/306/4678/+TSRAGRSN

Label	Notation	URI
Thunderstorm with heavy precipitation of snow, rain and hail	+TSSNRAGR	http://codes.wmo.int/306/4678/+TSSNRAGR
Thunderstorm with heavy precipitation of snow, hail and rain	+TSSNGRRA	http://codes.wmo.int/306/4678/+TSSNGRRA
Thunderstorm with heavy precipitation of hail, rain and snow	+TSGRRASN	http://codes.wmo.int/306/4678/+TSGRRASN
Thunderstorm with heavy precipitation of hail, snow and rain	+TSGRSNRA	http://codes.wmo.int/306/4678/+TSGRSNRA
Thunderstorm with heavy precipitation of rain, snow and snow pellets/small hail	+TSRASNGS	http://codes.wmo.int/306/4678/+TSRASNGS
Thunderstorm with heavy precipitation of rain, snow pellets/small hail and snow	+TSRAGSSN	http://codes.wmo.int/306/4678/+TSRAGSSN
Thunderstorm with heavy precipitation of snow, rain and snow pellets/small hail	+TSSNRAGS	http://codes.wmo.int/306/4678/+TSSNRAGS
Thunderstorm with heavy precipitation of snow, snow pellets/small hail and rain	+TSSNGSRA	http://codes.wmo.int/306/4678/+TSSNGSRA
Thunderstorm with heavy precipitation of snow pellets/small hail, rain and snow	+TSGSRASN	http://codes.wmo.int/306/4678/+TSGSRASN
Thunderstorm with heavy precipitation of snow pellets/small hail, snow and rain	+TSGSSNRA	http://codes.wmo.int/306/4678/+TSGSSNRA
Light precipitation of freezing drizzle	-FZDZ	http://codes.wmo.int/306/4678/-FZDZ
Light precipitation of freezing rain	-FZRA	http://codes.wmo.int/306/4678/-FZRA
Light unidentified freezing precipitation	-FZUP	http://codes.wmo.int/306/4678/-FZUP
Light precipitation of freezing drizzle and rain	-FZDZRA	http://codes.wmo.int/306/4678/-FZDZRA
Light precipitation of freezing rain and drizzle	-FZRADZ	http://codes.wmo.int/306/4678/-FZRADZ
Precipitation of freezing drizzle	FZDZ	http://codes.wmo.int/306/4678/FZDZ
Precipitation of freezing rain	FZRA	http://codes.wmo.int/306/4678/FZRA
Unidentified freezing precipitation	FZUP	http://codes.wmo.int/306/4678/FZUP
Precipitation of freezing drizzle and rain	FZDZRA	http://codes.wmo.int/306/4678/FZDZRA
Precipitation of freezing rain and drizzle	FZRADZ	http://codes.wmo.int/306/4678/FZRADZ
Heavy precipitation of freezing drizzle	+FZDZ	http://codes.wmo.int/306/4678/+FZDZ
Heavy precipitation of freezing rain	+FZRA	http://codes.wmo.int/306/4678/+FZRA
Heavy unidentified freezing precipitation	+FZUP	http://codes.wmo.int/306/4678/+FZUP
Heavy precipitation of freezing drizzle and rain	+FZDZRA	http://codes.wmo.int/306/4678/+FZDZRA
Heavy precipitation of freezing rain and drizzle	+FZRADZ	http://codes.wmo.int/306/4678/+FZRADZ
Duststorm	DS	http://codes.wmo.int/306/4678/DS
Heavy duststorm	+DS	http://codes.wmo.int/306/4678/+DS
Duststorm in the vicinity	VCDS	http://codes.wmo.int/306/4678/VCDS

Label	Notation	URI
Sandstorm	SS	http://codes.wmo.int/306/4678/SS
Heavy sandstorm	+SS	http://codes.wmo.int/306/4678/+SS
Sandstorm in the vicinity	VCSS	http://codes.wmo.int/306/4678/VCSS
Fog	FG	http://codes.wmo.int/306/4678/FG
Funnel cloud(s) (tornado or water-spout)	FC	http://codes.wmo.int/306/4678/FC
Funnel cloud(s) (tornado or water-spout)	+FC	http://codes.wmo.int/306/4678/+FC
Dust/sand whirls (dust devils)	PO	http://codes.wmo.int/306/4678/PO
Volcanic ash	VA	http://codes.wmo.int/306/4678/VA
Fog in the vicinity	VCFG	http://codes.wmo.int/306/4678/VCFG
Funnel cloud(s) (tornado or water-spout) in the vicinity	VCFC	http://codes.wmo.int/306/4678/VCFC
Dust/sand whirls (dust devils) in the vicinity	VCPO	http://codes.wmo.int/306/4678/VCPO
Volcanic ash in the vicinity	VCVA	http://codes.wmo.int/306/4678/VCVA
Thunderstorm	TS	http://codes.wmo.int/306/4678/TS
Thunderstorm in the vicinity	VCTS	http://codes.wmo.int/306/4678/VCTS
Shower(s) in the vicinity	VCSH	http://codes.wmo.int/306/4678/VCSH
Blowing sand in the vicinity	VCBLSA	http://codes.wmo.int/306/4678/VCBLSA
Blowing dust in the vicinity	VCBLDU	http://codes.wmo.int/306/4678/VCBLDU
Blowing snow in the vicinity	VCBLSN	http://codes.wmo.int/306/4678/VCBLSN
Blowing sand	BLSA	http://codes.wmo.int/306/4678/BLSA
Blowing dust	BLDU	http://codes.wmo.int/306/4678/BLDU
Blowing snow	BLSN	http://codes.wmo.int/306/4678/BLSN
Low drifting sand	DRSA	http://codes.wmo.int/306/4678/DRSA
Low drifting dust	DRDU	http://codes.wmo.int/306/4678/DRDU
Low drifting snow	DRSN	http://codes.wmo.int/306/4678/DRSN
Sand	SA	http://codes.wmo.int/306/4678/SA
Dust	DU	http://codes.wmo.int/306/4678/DU
Shallow fog	MIFG	http://codes.wmo.int/306/4678/MIFG
Partial fog (covering part of the aerodrome)	PRFG	http://codes.wmo.int/306/4678/PRFG
Patches of fog	BCFG	http://codes.wmo.int/306/4678/BCFG
Freezing fog	FZFG	http://codes.wmo.int/306/4678/FZFG
Mist	BR	http://codes.wmo.int/306/4678/BR
Haze	HZ	http://codes.wmo.int/306/4678/HZ
Smoke	FU	http://codes.wmo.int/306/4678/FU
Squalls	SQ	http://codes.wmo.int/306/4678/SQ

CODE TABLE D-7: CLOUD AMOUNT REPORTED AT AERODROME

The items within this code table are the cloud amount categories of operational significance for aviation as specified in Technical Regulations, Volume II (WMO-No. 49): Meteorological Services for International Air Navigation. This code table contains a subset of the cloud amount categories defined in Part B FM 94 BUFR Code table 0 20 008. Each code item is uniquely identified using a URI. The URI is also a URL providing additional information about the associated cloud amount category. This code table is published at http://codes.wmo.int/49-2/CloudAmountReportedAtAerodrome.

Label	Notation	URI	Description
Broken	BKN	http://codes.wmo.int/bufr4/codeflag/0-20-008/3	Broken (5-7 oktas).
Embedded	EMBD	http://codes.wmo.int/bufr4/codeflag/0-20-008/16	Embedded. Applicable only to cumulonimbus (CB).
Few	FEW	http://codes.wmo.int/bufr4/codeflag/0-20-008/1	Few (1-2 oktas).
Frequent	FRQ	http://codes.wmo.int/bufr4/codeflag/0-20-008/12	Frequent. Applicable only to cumulonimbus (CB).
Isolated	ISOL	http://codes.wmo.int/bufr4/codeflag/0-20-008/8	Isolated. Applicable only to cumulonimbus (CB).
Layers	LYR	http://codes.wmo.int/bufr4/codeflag/0-20-008/14	Layers. Applicable only to cumulonimbus (CB).
Occasional	OCNL	http://codes.wmo.int/bufr4/codeflag/0-20-008/10	Occasional. Applicable only to cumulonimbus (CB).
Overcast	OVC	http://codes.wmo.int/bufr4/codeflag/0-20-008/4	Overcast (8 oktas).
Scattered	SCT	http://codes.wmo.int/bufr4/codeflag/0-20-008/2	Scattered (3-4 oktas).
Sky clear	SKC	http://codes.wmo.int/bufr4/codeflag/0-20-008/0	Sky clear (0 oktas).

CODE TABLE D-8: SIGNIFICANT CONVECTIVE CLOUD TYPE

The items within this code table are the cloud types of operational significance for aviation as specified in Technical Regulations, Volume II (WMO-No. 49): Meteorological Services for International Air Navigation. This code table contains a subset of the cloud types defined in Part B FM 94 BUFR Code table 0 20 012. Each cloud type is uniquely identified using a URI. The URI is also a URL providing additional information about the associated cloud type. This code table is published at http://codes.wmo.int/49-2/SigConvectiveCloudType.

Label	Notation	URI	Description
Cumulonimbus	CB	http://codes.wmo.int/bufr4/codeflag/0-20-012/9	A principal cloud type, exceptionally dense and vertically developed, occurring either as isolated clouds or as a line or wall of clouds with separated upper portions.
Towering cumulous	TCU	http://codes.wmo.int/bufr4/codeflag/0-20-012/32	Cumulus mediocris or congestus, towering cumulus (TCU), with or without Cumulus of species fractus or humilis or Stratocumulus, all having their bases at the same level.

CODE TABLE D-9: SIGNIFICANT WEATHER PHENOMENA

The items within this code table are the types of weather phenomena of significance to aeronautical operations – as used in SIGMET and AIRMET reports and specified in Technical Regulations, Volume II (WMO-No. 49), Part II, Appendix 6, [C.3.1.] 1.1.4. Each weather phenomenon type is uniquely identified using a URI. The URI is also a URL providing additional information about the associated weather phenomena type. This code table is published at http://codes.wmo.int/49-2/SigWxPhenomena.

Label	Notation	URI	Description
Embedded thunderstorm	EMBD_TS	http://codes.wmo.int/49-2/SigWxPhenomena/EMBD_TS	
Embedded thunderstorm with hail	EMBD_TSGR	http://codes.wmo.int/49-2/SigWxPhenomena/EMBD_TSGR	
Frequent thunderstorm	FRQ_TS	http://codes.wmo.int/49-2/SigWxPhenomena/FRQ_TS	
Frequent thunderstorm with hail	FRQ_TSGR	http://codes.wmo.int/49-2/SigWxPhenomena/FRQ_TSGR	
Heavy dust storm	HVY_DS	http://codes.wmo.int/49-2/SigWxPhenomena/HVY_DS	
Heavy sand storm	HVY_SS	http://codes.wmo.int/49-2/SigWxPhenomena/HVY_SS	
Obscured thunderstorm	OBSC_TS	http://codes.wmo.int/49-2/SigWxPhenomena/OBSC_TS	
Obscured thunderstorm with hail	OBSC_TSGR	http://codes.wmo.int/49-2/SigWxPhenomena/OBSC_TSGR	
Radioactive cloud	RDOACT_CLD	http://codes.wmo.int/49-2/SigWxPhenomena/RDOACT_CLD	

Label	Notation	URI	Description
Severe airframe icing	SEV_ICE	http://codes.wmo.int/49-2/SigWxPhenomena/SEV_ICE	
Severe airframe icing from freezing rain	SEV_ICE_FZRA	http://codes.wmo.int/49-2/SigWxPhenomena/SEV_ICE_FZRA	
Severe mountain wave	SEV_MTW	http://codes.wmo.int/49-2/SigWxPhenomena/SEV_MTW	
Severe turbulence	SEV_TURB	http://codes.wmo.int/49-2/SigWxPhenomena/SEV_TURB	
Squall line	SQL_TS	http://codes.wmo.int/49-2/SigWxPhenomena/SQL_TS	
Squall line with hail	SQL_TSGR	http://codes.wmo.int/49-2/SigWxPhenomena/SQL_TSGR	
Tropical cyclone	TC	http://codes.wmo.int/49-2/SigWxPhenomena/TC	
Volcanic ash	VA	http://codes.wmo.int/49-2/SigWxPhenomena/VA	

APPENDIX B. DEFINITION OF SCHEMAS

[Note to editors: the contents of the sub-sections are URLs. They must not be translated]

1 COLLECT-XML

1.1 http://schemas.wmo.int/collect/1.1/collect.xsd

2 METCE-XML (MODÉLE POUR L'ÉCHANGE DES INFORMATIONS SUR LE TEMPS, LE CLIMAT ET L'EAU)

2.1 http://schemas.wmo.int/metce/1.1/metce.xsd

2.2 http://schemas.wmo.int/metce/1.1/procedure.xsd

2.3 http://schemas.wmo.int/metce/1.1/phenomena.xsd

3 OPM-XML (MODÉLE POUR L'ÉCHANGE DES INFORMATIONS SUR LE TEMPS, LE CLIMAT ET L'EAU)

3.1 http://schemas.wmo.int/opm/1.1/opm.xsd

3.2 http://schemas.wmo.int/opm/1.1/observable-property.xsd

4 SAF-XML (SIMPLE AERONAUTICAL FEATURES)

4.1 http://schemas.wmo.int/saf/1.1/saf.xsd

4.2 http://schemas.wmo.int/saf/1.1/dataTypes.xsd

4.3 http://schemas.wmo.int/saf/1.1/features.xsd

4.4 http://schemas.wmo.int/saf/1.1/measures.xsd

5 IWXXM-XML (ICAO METEOROLOGICAL INFORMATION EXCHANGE MODEL)

5.1 http://schemas.wmo.int/iwxxm/1.1/iwxxm.xsd

5.2 http://schemas.wmo.int/iwxxm/1.1/common.xsd

5.3 http://schemas.wmo.int/iwxxm/1.1/metarSpeci.xsd

5.4 http://schemas.wmo.int/iwxxm/1.1/taf.xsd

5.5 http://schemas.wmo.int/iwxxm/1.1/sigmet.xsd

Annex 2 to Recommendation 10 (CBS-Ext.(2014))

GUIDELINES ON WMO DATA MODELLING FOR WMO CODES

The text of the G*uidelines on Data Modelling for WMO Codes* will be published only in English.

GUIDELINES ON DATA MODELLING FOR WMO CODES

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1 INTRODUCTION

1.1 Context

The word *codes* is used in many different contexts within the work of the WMO. There are lists of values named “code lists,” and multi-page documents that describe “code forms” (binary and alphanumeric) for data interchange. The matter is further complicated by the term “source code” for computer software. The title of this document refers to “WMO codes,” and it is intended to have two meanings. First, this document explains the strategies applied to create data models for a handful of important Traditional Alphanumeric Codes (TAC). Second, this document explains strategies that can be used as data modellers create entirely new data representations.

1.2 History

In July 2011, the WMO’s Commission for Basic Systems’ Management Group (CBS-MG) created the Task Team on Aviation XML (TT-AvXML) at its twelfth meeting. TT-AvXML was “to harmonize with ICAO an XML representation of weather data that could be used within the aviation community.” In accordance with its terms of reference, the team chose a data modelling approach that would “allow consistency with the emerging WMO data model...and allow consistent evolution alongside other WMO data representations…”

It was urgent for TT-AvXML to produce specifications of Geography Markup Language (GML)/eXtensible Markup Language (XML) schemas for the encoding of four key TAC forms. These code forms were METAR, SPECI, TAF, and SIGMET. ICAO needed these schemas to support Amendment 76 to ICAO Annex 3 – *Meteorological Service for International Air Navigation*. Specifically, Amendment 76 enabled "States in a position to do so" to disseminate these products "formatted in accordance with a globally interoperable information exchange model" that would "use extensible markup language (XML)/geography markup language (GML)."

Rather than create XML schemas directly, TT-AvXML chose to follow industry best practices and first create its data model within Unified Modelling Language (UML) and then generate XML schemas automatically using a defined set of rules. The Task Team also chose to establish a codes registry to host authoritative terms from WMO technical regulations as web-accessible resources that could be referenced from within these new data products.

1.3 Data Modelling and WMO Governance

The WMO has played a strong role in codifying weather, water, and climate concepts and procedures as well as developing data representations. This work has enabled the WMO to successfully facilitate the free and unrestricted exchange of products and services in real-time and near-real time with strong governance for decades. The code tables that form the underpinning of the WMO’s Table-Driven Code Forms (TDCF; e.g., GRIB and BUFR) have been called the WMO’s “crown jewels.” Decades of expert effort have established authoritative terminologies that describe phenomena in these domains.

The data models described herein have been built upon many of these same concepts. The generic classes presented here are intended to be useful across the regimes governed by the WMO and other regimes. While the WMO governs the classes contained in these data models, many useful definitions are imported from various reference models governed by the International Organization for Standardization (ISO) Technical Committee 211 (TC211). Developers have drawn inspiration from WMO TDCFs for much of this work.

1.4 Overview

This document is intended to guide people who want to create data representations. Most of the examples used here come from the four TAC that were modelled in AvXML. We offer these models as examples of best practice. Moreover, we hope that many readers will learn and understand more readily because they are familiar with TAC. Sections 2 and 3 introduce the METCE and OPM models, respectively. These are foundational tools for WMO data modelling. Section 4 provides substantial detail about the data modelling process. This includes an important discussion about the various properties of the Observation and Measurements model and how it can be applied to WMO domains. Section 5 introduces the WMO Codes Registry, another useful tool for WMO data modellers. Annexes A through G document METCE, OPM, and IWXXM in considerable detail. The reader should note that the information available in Annexes A through G is also available online. Moreover, the online versions are superior to the print versions. These annexes contain context diagrams and descriptive tables. Annex H documents the techniques used to create XML schemas from the AvXML model.

1.5 Reference standards

The following data models have all been useful in modelling WMO codes:

ISO 8601, Data elements and interchange formats – Information interchange – Representation of dates and times

ISO 19109:2005, Geographic information – Rules for application schema

ISO 19136:2007, Geographic information – Geography Markup Language (GML)

ISO/TS 19139:2007, Geographic information – Metadata – XML schema implementation

ISO 19156:2011, Geographic information – Observations and measurements

ISO/IEC 19757-3:2006 Information technology – Document Schema Definition Language (DSDL) – Part 3: Rule-based validation – Schematron

OGC/IS 10-025r1 Observations and measurements v2.0 – XML implementation

OGC/IS 08-094r1 SWE Common Data Model

W3C XMLName, Namespaces in XML. W3C Recommendation (14 January 1999)

W3C XMLSchema-1, XML Schema Part 1: Structures. W3C Recommendation (2 May 2001)

W3C XMLSchema-2, XML Schema Part 2: Datatypes. W3C Recommendation (2 May 2001)

W3C XML, Extensible Markup Language (XML) 1.0 (Second Edition). W3C Recommendation (6 October 2000)

W3C XLink, XML Linking Language (XLink) Version 1.1. W3C Recommendation (6 May 2010)

1.6 Special role of the Observations and Measurements Model in WMO Data Modelling

WMO data models are built on the foundation provided by ISO 19156:2011 "Geographic information — Observations and measurements" (O&M). O&M models many useful concepts and organises them into classes that complement and support the development of WMO codes. As the

originator of this ISO standard, the Open Geospatial Consortium (OGC) has published a "sister document" named Topic 20: Observations and Measurements. OGC Topic 20 contains much of the information of ISO 19156:2011, supplemental material, and an XML implementation.

By far, the portion of O&M that is most relevant to modelling WMO codes is the class named OM_Observation.

OM_Observation is remarkably well suited to the representation of WMO codes. Despite its name, O&M supports both observations and forecasts of weather, water, and climate. The OM_Observation class provides a framework to describe the *event* of an observation or measurement. In O&M, an **observation** is defined as an event that results in an estimation of the value (the **result**) of a property (the **observed property**) of some entity (the **feature of interest**) using a specified **procedure**. OM_Observation also provides a mechanism to capture quality information about the result and arbitrary **parameters** concerning the observation event. OM_Observation includes three different time attributes. The **phenomenon time** is the time that the result applies to the property of the feature of interest. The **result time** is the time when the result became available. The **valid time** is the period during which the result is intended to be used.

OM_Observation allows one to describe arbitrarily complex procedures. It can describe the measurement of air temperature using a particular type of thermometer, and it can describe intensive numerical simulations. Many forms of observations are represented using WMO code forms. O&M provides a framework that can support them all.

Note: Some of the terminology (in particular, result time, phenomenon time, valid time) established in O&M differs from and conflicts with terminology previously established in WMO publications.

2 MODÈLE POUR L'ÉCHANGE DES INFORMATIONS SUR LE TEMPS, LE CLIMATE ET L'ÉAU (METCE)

The Modèle pour l'Échange des Informations sur le Temps, le Climate et l'Éau (METCE) is a Logical Data Model (LDM) that was developed to work within the O&M framework and support WMO domains. In English, METCE may also be known as the "METeorological Community Exchange" model. The classes and concepts found in METCE will be especially useful to those who are developing data models for pre-existing Traditional Alphanumeric Codes (TAC) and Table-Driven Code Forms (TDCF). METCE will serve equally well developing new data representations.

2.1 Purpose and use of METCE

METCE provides an information framework that will be useful when applying O&M to the task of modelling WMO codes. It contains three parts.

The first part of METCE is a series of definitions of observation/forecast types. In this context, the word *type* refers explicitly to the optional type sub-element defined in the OGC project document named "Observations and Measurements – XML Implementation" (OMXML; OGC 10-025r1). These types are defined authoritatively by the WMO Registry (http://codes.wmo.int). An initial set of types has been defined, at this writing, and they are described below.

The second part of METCE is a data model for certain meteorological phenomena. Version 1.1 (namespace http://def.wmo.int/metce/2013) of METCE currently contains a limited number of features (e.g. volcano and tropical cyclone) that were required to model METAR, SPECI, TAF, and SIGMET. There are many other features, however, that can be modelled in this way. They will likely be added as a part of subsequent releases.

The third part of METCE includes a data model for procedures. This is a concrete implementation of the OM_Process class found in O&M.

The METCE application schema will typically be imported to provide a baseline conceptual model framework upon which community-specific application schema can be built.

2.2 Observation/Forecast Types Defined in METCE

The UML data model for METCE (See Annex A, below.) clearly illustrates the structure and intended uses for the observation/forecast types. The types are named metce:Sampling-Observation, metce:ComplexSamplingMeasurement, and metce:SamplingCoverageMeasurement. All three types are specialisations of O&M. All three are formed by limiting options for om:result, om:featureOfInterest, and/or om:process.

2.2.1 ComplexSamplingMeasurement

ComplexSamplingMeasurement (a subclass of OM_ComplexObservation) should be used when a single observation event evaluates multiple parameters. Examples include a set of measurements taken by instruments mounted on a tower and a forecast of rainfall and wind speed at an aerodrome. It imposes the following three constraints: 1) the result (om:result) is a Record, as defined in ISO 19103; 2) the feature of interest (om:featureOfInterest) belongs to the class SF_SpatialSamplingFeature, as defined in O&M, or to a subclass of SF_SpatialSamplingFeature; and 3) the procedure (om:procedure) belongs to the class Process, as defined in METCE, or to a subclass of Process. The OM_ComplexObservation is used because the result of this class is a group of measures, provided as a Record. Again, this matches many WMO application domains

where multiple phenomena are measured or forecast simultaneously as a single observation event.

2.2.2 SamplingCoverageMeasurement

SamplingCoverageMeasurement (a subclass of OM_DiscreteCoverageObservation) should be used when the observation/forecast event evaluates parameters that vary over space and/or time. Examples include sea surface temperatures from a drifting buoy and a forecast grid from a Numerical Weather Prediction (NWP) system. It imposes the following three constraints: 1) the result (om:result) is a discrete coverage (CV_DiscreteCoverage), as defined in ISO 19123; 2) the feature of interest (om:featureOfInterest) belongs to the class SF_SpatialSamplingFeature, as defined in O&M, or to a subclass of SF_SpatialSamplingFeature; and 3) the procedure (om:procedure) belongs to the class Process, as defined in METCE, or to a subclass of Process.

2.2.3 SamplingObservation

SamplingObservation (a subclass of OM_Observation) provides a general purpose observation/forecast type. It imposes only two constraints: 1) the feature of interest (om: featureOfInterest) belongs to the class SF_SpatialSamplingFeature, as defined in O&M, or to a subclass of SF_SpatialSamplingFeature; and 2) the procedure (om:procedure) belongs to the class Process, as defined in METCE, or to a subclass of Process. SamplingObservation is especially well suited to applications where the result of the observation/forecast (om:result) is not a number. E.g., IWXXM uses this observation/forecast type to model the aviation product named SIGMET. A SIGMET warns pilots of dangerous weather conditions over specific regions of airspace and spans of time. Of course, SamplingObservation can also support numerical observations/forecasts, i.e., a river gage reading.

2.2.4 Notes on observation/forecast types

Developers who want to use these various METCE types will need to choose among them. For those observations and forecasts where the result is expected to vary over space and time, SamplingCoverageMeasurement is the only suitable option. If the result is confined to a single point in space and a single moment in time, then SamplingObservation and ComplexSampling-Measurement are possibilities. One should choose between these two types by considering the number of parameters that will be evaluated. ComplexSamplingMeasurement records multiple parameters in a Record. SamplingObservation imposes no constraints on the results, making it the most flexible (least constrained).

It is notable that all three METCE observation/forecast types require the feature of interest to be a member of the class SF_SpatialSamplingFeature or a subclass of SF_SpatialSamplingFeature. SF_SpatialSamplingFeature is especially well-suited to the domains of interest to the WMO. Measurements from a set of instruments mounted at a fixed point on the earth's surface can be modelled with a combination of SF_SpatialSamplingFeature and GM_Point. Observations from a moving platform, i.e. an aircraft or ship or weather balloon, can be modelled with a combination of SF_SpatialSamplingFeature and GM_Curve. In these cases, we generally seek information about large expanses of atmosphere or ocean, but our observations sample a small fraction of the domain.

There are use cases, however, in the WMO domains of interest where the notion of sampling is not appropriate. A weather service may issue a warning for some form of severe weather that applies to an entire geopolitical region. The basin-average precipitation accumulation could be observed, analysed, or forecast over a river basin. In these cases, it may not be appropriate to model the feature of interest (om:featureOfInterest) with the class SF_SpatialSamplingFeature. In these instances, the METCE types will not be useful. Rather, the data modeller should use the appropriate GFI_Feature from O&M. These are modelled in XML with the class gml: AbstractFeature.

2.3 Data Model for Meteorological Phenomena

The Data Model for Meteorological Phenomena includes features that play a significant role on meteorology (e.g., volcanoes and tropical cyclones). The phenomena listed in version 1.1 of METCE (namespace http://def.wmo.int/metce/2013) are taken from WMO No. 306 Vol I.2 FM 94 BUFR code-table 0 08 011 "Meteorological Feature." Code table 0 08 011 includes items such as cold front at the surface, jet stream, mountain wave, and sandstorm. Some or all of these features may be added to the Data Model for Meteorological Phenomena in future releases.

2.4 Data Model for Procedures

The Data Model for Procedures provides a concrete implementation of the abstract OM_Process class (from O&M). The model provides a reference to supporting documentation about the observation/forecast. Typically, this will be a URL that points to a web page that contains documentation. The Data Model for Procedures also contains a number of parameters that describe the measuring process. These include the resolution and the measuring interval of the measurement. Other parameters can be defined and recorded through a soft typing method.

The concept of measuring interval is useful in cases where the smallest and/or largest reported values are determined by some prior agreement or regulation. E.g., aviation regulations (Annex 3 to the Convention on International Aviation) impose a measurement interval of 0 – 10 km on visibilities in the METAR, SPECI, and TAF codes. It is likely that the instruments used to make the measurements can accurately measure visibilities greater than 10 km. Regulation, however, restricts the reported values.

2.5 Location of class definitions and context diagrams for METCE

The authoritative version of the METCE is maintained within IWXXM as an online resource at the following URL: http://wis.wmo.int/AvXML/AvXML-1.1/index.htm. An abridged version of the METCE class diagrams and context diagrams are provided in Annex A.

3 OBSERVABLE PROPERTY MODEL

The Observable Property Model (OPM) was developed within the OGC Sensor Web Enablement Standards Working Group & INSPIRE Thematic Working Groups. By agreement between OGC and WMO, OPM is governed by WMO.

Data modellers can use OPM to aggregate observed physical properties into composite properties (CompositeObservableProperty). OPM also provides the tools needed to explicitly describe any qualifications or constraints imposed upon these physical properties. Finally, OPM allows each physical property to be qualified according to its specific observation context. E.g. within a METAR, the property wind speed is formally defined as the mean wind speed within the 10-minute period preceding the observation.

OPM is not used within the ICAO Meteorological Information Exchange Model (IWXXM). The schema validation needs and strict regulation practices led to a hard-typing approach for IWXXM. OPM is included in this distribution to support the development of other application schemas.

3.1 Purpose and use of OPM

OPM supports two functions--aggregation and constraint.

3.1.1 Parameter aggregation and CompositeObservableProperty

OPM defines a CompositeObservableProperty class that supports the aggregation of observed physical properties into composites. A data publisher may need to use the OPM, if the observation results in the evaluation of multiple parameters, to define each of those individual parameters.

Note that in the case of class Process, there is no constraint on the number of occurrences of a given parameter name. However, recommended practice indicates the use of an instance of Class CompositeObservableProperty where a set of observable properties are to be specified.

3.1.2 Parameter qualification and QualifiedObservableProperty

OPM also defines a QualifiedObservableProperty that supports spatial aggregations, temporal aggregations, statistical functions, and constraints. (Those who are familiar with GRIB2 encoding may note a similarity between OPM's QualifiedObservableProperty and the concept of "average, accumulation, extreme values or other statistically processed values" found in some Product Definition Templates.)

A data publisher may need to use the OPM to explicitly define any qualification or constraint applied to the observed property. Examples include explicitly declaring the averaging period of a wind observation, representing precipitation accumulation over a period of time, and representing maximum/minimum temperatures.

3.2 Location of class definitions and context diagrams for OPM

The authoritative version of the OPM is maintained within AvXML as an online resource at the following URL: http://wis.wmo.int/AvXML/AvXML-1.1/index.htm. An abridged version of the OPM class diagrams and context diagrams are provided in Annex B.

4 DEVELOPMENT OF NEW DATA REPRESENTATIONS WITH METCE AND OPM

As stated above, O&M provides a data modelling framework that can support most, if not all, WMO code forms. Moreover, the tools provided by METCE and OPM further support these efforts. WMO data generally fall into three broad categories, i.e., observations, analyses, and forecasts. In this section, we will provide concrete suggestions on applying O&M, METCE, and OPM to these three categories.

Data modellers who are developing new representations of WMO codes are encouraged to build their model first in UML, and then use automated techniques to create one or more data representations. The use of an abstract data model combined with a software implementation of the data representation provides a great deal of flexibility to organisations. These tools enable a quicker response when technologies evolve. E.g., TT_AvXML chose to use the commercial data modelling tool named Enterprise Architect to build its UML models. (Reference to names of firms and commercial products and process does not imply their endorsement by WMO, and any failure to mention a firm, commercial product or process is not a sign of disapproval.) Then, TT_AvXML used a software package named Fullmoon to convert the UML into XML schemas. If there were a need for other representations (say, JSON), additional software techniques would be able to generate those new representations from that same UML model.

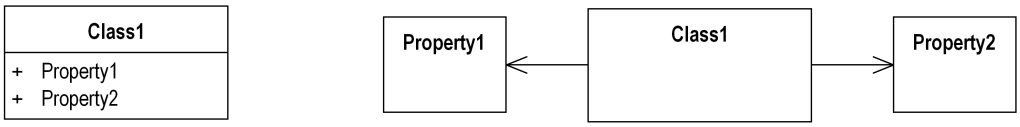
Data modellers who are developing new representations of WMO codes are also encouraged to maximise use of the WMO Registry, described below, when formulating their data representations. The WMO Registry provides a web-enabled link to the large number of well-defined physical quantities. The combination of OPM and the registry should serve the needs of most WMO data modellers.

4.1 UML notation

UML notation is used freely throughout the annexes of this document, and it may be somewhat unfamiliar to the reader. Figures 1, 2, and 3 are offered here as a much abbreviated introduction to UML class diagrams with a focus on the constructs used elsewhere in this document. See Chapter 3 of *UML Distilled* (Fowler 2004) for a more thorough introduction to the topic.

class UML Notation 1

We begin by noting that all classes have properties. These properties can be described as either attributes or associations. The two diagrams below both show a class with two properties.



The attributes described within a class normally include additional information about data types and multiplicity. (Multiplicity is sometimes called cardinality.)

In the class, below, Property1 can occur only once, Property2 can occur one or more times, Property3 can occur zero or more times, Property4 must occur three times, and Property5 can occur zero or one times.

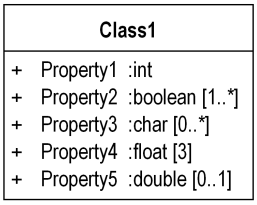
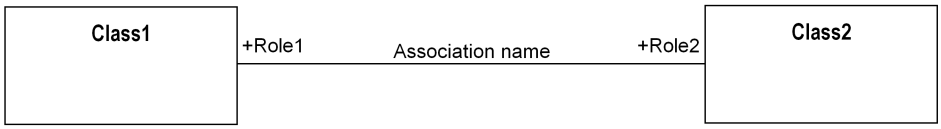


Figure 1: UML classes and properties

class UML Notation 2

Associations can include names, roles, and multiplicities. The association below is undirected.



Directed associations are quite common in WMO data models. In the example below Class1 includes an optional property named Class2.

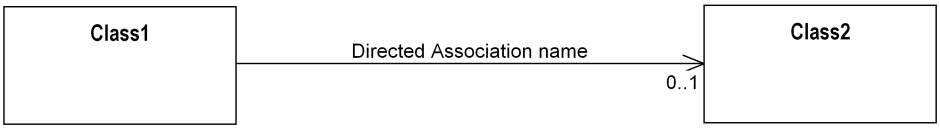


Figure 2: UML associations

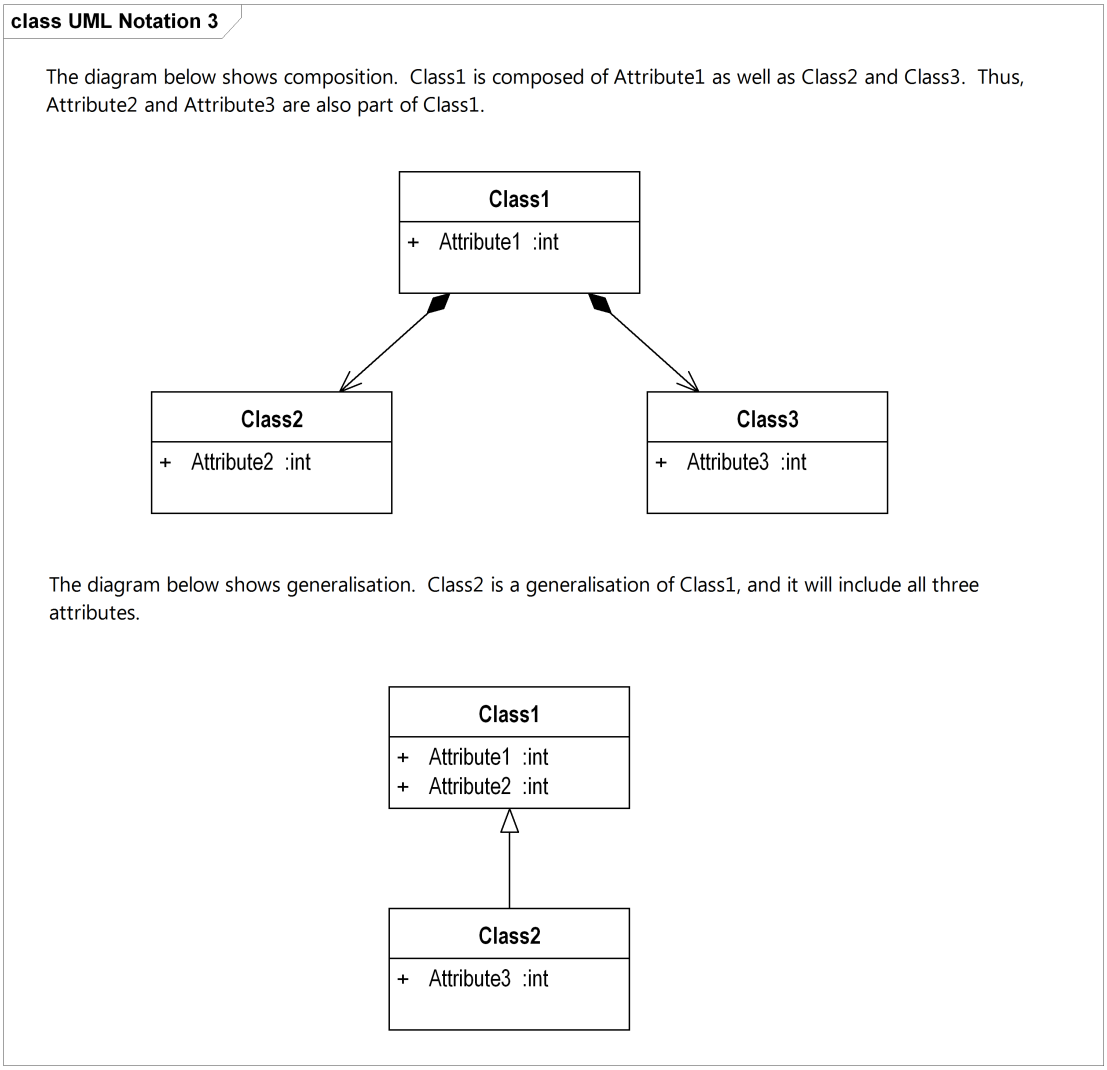


Figure 3: UML composites and generalisations

4.2 Overall considerations

As stated previously, O&M is well-suited to most data modelling tasks for WMO codes. One of the three O&M types defined in METCE will also be useful in most of these applications. The data modeller should consider the following points when planning his/her strategy:

The three METCE types named metce:SamplingObservation, metce:ComplexSampling-Measurement, and metce:SamplingCoverageMeasurement all require the O&M property named om:procedure to be of type metce:Process. If metce:Process is not suitable for the project at hand, then these types should not be used.

The same three METCE types require the O&M property named om:featureOfInterest to be of type SF_SpatialSamplingFeature. If SF_SpatialSamplingFeature is not suitable, then these types should not be used.

The METCE type named metce:ComplexSamplingMeasurement requires the om:result to be of type Record. This enables a single observation/analysis/forecast to contain multiple physical quantities.

The METCE type named metce:SamplingObservation imposes no constraints on the om:result.

The METCE type named metce:SamplingCoverageMeasurement requires the O&M property named om:result to of type CV_DiscreteCoverage.

If one of these three METCE observation types is selected, the O&M element named type should be set, as follows:

<om:type xlink:href="http://codes.wmo.int/common/observation-type/METCE/2013/ComplexSamplingMeasurement">
<om:type xlink:href=http://codes.wmo.int/common/observation-type/METCE/2013/SamplingCoverageMeasurement>
<om:type xlink:href=http://codes.wmo.int/common/observation-type/METCE/2013/SamplingObservation>

4.3 The application of O&M properties to WMO data modelling

Much of this section will refer to the various O&M properties depicted in Figure 2 of the O&M documentation (The basic Observation type). The reader will benefit if a copy of the figure is available for reference.

4.3.1 om:phenomenonTime

O&M defines phenomenonTime as "the time that the result…applies to the property of the feature-of-interest…" If we are modelling an observation, then this is the time when the physical parameter was observed. If we are modelling an analysis, then this is the time when the analysis applies to the "real world." If we are modelling a forecast, then this is the time when we expect events will happen. For most earth science applications, we can expect phenomenonTime to be in the past for observations and analyses, and in the future for forecasts.

Because O&M defines phenomenonTime to be of type TM_Object, it can be either an instant in time or a span of time. One and only one phenomenonTime must appear in an OM_Observation.

4.3.2 om:resultTime

O&M defines resultTime as "the time when the result became available." If we are modelling an observation, then this time may well match the phenomenonTime. If we are modelling an analysis, then is the time when the analysis process completed. If we are modelling a forecast, then this is the time when the forecast became available. We can generally expect resultTime to be in the past.

ResultTime is defined to be of type TM_Instant. Thus, it must be a point in time. One and only one resultTime must appear in an OM_Observation.

4.3.3 om:validTime

Note: The definition of validTime found in O&M differs considerably from the definitions of concepts with similar names found in other WMO documents. Those who produce data within this framework should take special care to help their customers interpret all time concepts correctly.

O&M defines validTime as "the time period during which the result is intended to be used." It goes on to say that validTime "is commonly required in forecasting applications."

ValidTime is defined to be of type TM_Period. Thus, it must be a span of time. ValidTime is an optional attribute. It may be omitted. If present, only one instance may appear.

For most earth science applications, validTime will be omitted from observations and analyses. This assumes that observations and analyses are useful for indefinite periods of time.

There are two strategies for validTime that seem appropriate when modelling forecasts. First, we can set validTime to begin with the resultTime and end with the phenomenonTime. I.e., our customers should use our forecast while it is still a forecast. In operational environments, a second strategy may be more useful to customers. We can limit the validTime to a shorter time period that ends when we expect a newer (and, presumably, better) forecast will be available.

4.3.4 Examples and times

WMO code forms are used to represent a number of different observations. When these observations are modelled with OM_Observation, their phenomenon time and result time will be generally be close to each other or identical. When output from a Numerical Weather Prediction (NWP) is modelled with OM_Observation, the result time will represent the time when the NWP simulation ended and the output became available, and the phenomenon time will be a time in the future when the NWP forecast will be valid. When a human generated forecast is modelled with OM_Observation, the result time will represent the time when the forecast was available for use, and the phenomenon time will be a time in the future when conditions are forecast to occur.

4.3.5 om:resultQuality

O&M defines resultQuality simply as describing “the quality of the result.” O&M goes on to note that resultQuality is “instance-specific” and “complements the description.” Information about “the quality of all observations using this procedure” should be modelled in om:procedure. ResultQuality should focus on the quality of the specific observation at hand.

ISO 19157:2011 *Geographic Information—Data quality* provides a substantial toolset for modelling data quality. ResultQuality is of type DQ_Element. It may be omitted, and more than one DQ_Element may appear.

4.3.6 om:procedure

O&M requires that each observation has one and only one property named procedure. Data modellers have a great deal of flexibility when encoding procedure in an observation. The class specified for procedure is OM_Process. OM_Process, in turn is abstract, lacking attributes, operations, associations.

Simple strategies for encoding procedure include the following: 1) encode a text description of the observing process, 2) encode a text description of a document that describes the observing process, and 3) encode a URL that points to the description.

As noted above, the three WMO observation types (metce:SamplingObservation, metce:Complex-SamplingMeasurement, and metce:SamplingCoverageMeasurement) all require that om:procedure be encoded as metce:Process.

There are other, more complex, strategies available for encoding procedure. ISO 19115-2:2009 *“Geographic information—Metadata—Part 2: Extensions for imagery and gridded data”* provides the following classes that can be useful for modelling the procedure: MI_Instrument, LE_Processing, and LE_Algorithm. The OGC standard named SensorML includes additional tools.

4.3.7 om:observedProperty

Like procedure, O&M requires that each observation include one and only one instance of observedProperty. Also like procedure, data modellers have substantial flexibility when implementing observedProperty. The class specified for observedProperty is GFI_PropertyType.

Data modellers who are implementing new or existing WMO codes are encouraged to maximize their use of the WMO Registry (See below.) when encoding observedProperty. Many, many observable properties have been catalogued in WMO tables and manuals. Authoritative, web-accessible versions of these tables and manuals are hosted within the registry.

4.3.8 om:featureOfInterest

O&M requires one and only one featureOfInterest, and its type is the general GFI_Feature. For many earth science applications where the feature being observed is a spatial proxy for a real-world feature, the class SF_SpatialSamplingFeature will serve nicely to encode featureOfInterest. As noted above, SF_SpatialSamplingFeature is required for any of the three WMO observation types defined in METCE (metce:SamplingObservation, metce:ComplexSamplingMeasurement, and metce:SamplingCoverageMeasurement).

4.3.9 om:result

O&M requires one and only one result, and it may be of any type. In cases where many physical quantities are observed simultaneously as part of a single observation, the type Record seems appropriate. The METCE type named metce:ComplexSamplingMeasurement requires that result be of type Record or a subclass of Record.

4.3.10 om:metadata

The O&M property named metadata is optional. If it is encoded, only one instance may appear, encoded with the MD_Metadata class found in ISO 19115 *"Geographic information—Metadata."*

4.3.11 om:relatedObservation

The O&M property named relatedObservation is optional. It is used to relate one observation to another observation with an attribute that describes the role one plays in understanding the other.

O&M says that "Some observations depend on other observations to provide context…These dependencies are stronger than mere spatiotemporal coincidences…"

4.3.12 om:parameter

O&M provides a mechanism for modelling additional properties with a data type called NamedValue. A NamedValue has two attributes, a generic name called "name" and a "value" of type Any. This gives a great deal of flexibility to the data modeller. Om:parameter should capture event-specific and/or contextual parameters.

It is easy to see how named parameters might be useful in representing WMO codes. The following table was created by considering Product Definition Template (PDT) 4.1 in GRIB2, Individual ensemble forecast, control and perturbed, at a horizontal level or in a horizontal layer at a point in time. For this illustration, assume we are encoding data for a single point that was generated by an Ensemble Forecast System (EFS).

parameter.name	Data Type	GRIB2 Contents	Comments
analysis time	TM_Instant	reference time	Not modelled by existing O&M times.
data cutoff time	TM_Instant	Hours/minutes after reference time of data cutoff	Not modelled by existing O&M times.
ensemble forecast type	Code table	Type of ensemble forecast	Could also be modelled as part of om:procedure.
perturbation number	int	Perturbation number	
ensemble size	int	Number of forecasts in ensemble	

4.3.13 om:type

The element om:type does not appear in the ISO 19156 document. It does appear, however, in OGC's Topic 20. Thus, it is implemented in the XML schemas. The 2013 version of METCE defined three observation types. They are described above, and they are documented authoritatively at http://codes.wmo.int/common/observation-type/METCE/2013. Additional types, defined by OGC, can be found at http://www.opengis.net/def/observationType/OGC-OM/2.0/.

4.4 Strong typing versus weak typing

Most data modellers can intuitively appreciate the concepts of "strong" and "weak" typing as they apply to data representation. For purposes of this discussion, we propose the following two delineations:

A strongly typed data representation strictly defines the elements that may appear and their data types.

A weakly typed data representation permits considerable flexibility in both elements and data types.

These statements are intended to be informative, not definitive. Practitioners can differ in their evaluation of any given data model. The purpose of this discussion is to inform data modellers of their options, and to provide examples of appropriate applications of each.

Below, we present a small portion of the ICAO Meteorological Information Exchange Model (IWXXM) as an example of a strongly typed data representation. IWXXM was intended to represent a set of four TAC, METAR, SPECI, TAF, and SIGMET. Historically, TACs have been defined strictly. Typical definitions include element order, units of measure, and numerical precision. As IWXXM was developed, ICAO representatives made it clear to the data modellers that the resulting XML schemas should enforce strong data typing. By way of contrast, we will also present an example that encodes the same information using methods of weak typing.

4.4.1 Advantages and disadvantages

Strongly typed data models generally sacrifice flexibility to gain efficiency. If the elements, their order, and their encoding are well known and understood at the time the data representations are modelled, strong typing can produce small, predictable messages. Strongly typed data models are also easier to process since the software only needs to accommodate a limited number of options. Strong typing was a clear choice for IWXXM since it was based on TACs that had seen little change in decades.

Data modellers should also consider how data consumers will use the information. E.g., there are few applications that need a latitude value without an accompanying longitude and coordinate reference system. Likewise, most consumers who request a wind direction will also need the associated wind speed. Strong typing strategies help the data modeller "keep things together."

Conversely, weakly typed data models emphasize flexibility over efficiency. Weak typing strategies are generally favoured in applications where data consumers choose a set of elements from a list at the time the data are requested. Data producers and data consumers must expend additional compute resources to support weakly typed data representations.

The decision on whether to use strong or weak typing in a model is not a single decision. A decision to use strong typing may apply to a complete model, but often the decision to use strong or weak typing is made for each element of the model on its merits.

A complete discussion of trade-offs for strong and weak typing is beyond the scope of this document. There are many other aspects to consider when deciding on whether to use strong or weak typing. Additional discussion points include (among others): where requirements for the

model are fixed or highly mutable, whether the model will be extended and managed by others, management of concepts inside vs outside the model (i.e., registries), the importance of verifying correctness of messages, and others.

4.4.2 An example of strong typing

The following fragment of XML schema code is taken from IWXXM:

```
<complexType name="CloudLayerType">
  <sequence>
    <element name="amount" type="iwxxm:CloudAmountReportedAtAerodromeType">
    </element>
    <element name="base" nillable="true" type="saf:DistanceWithNilReasonType">
      <annotation>
        <appinfo>
          <quantity>
            http://codes.wmo.int/common/quantity-kind/heightOfBaseOfCloud
          </quantity>
        </appinfo>
      </annotation>
    </element>
    <element maxOccurs="1" minOccurs="0" name="cloudType"
      type="iwxxm:SigConvectiveCloudTypeType">
    </element>
  </sequence>
</complexType>
<complexType name="SigConvectiveCloudTypeType">
  <annotation>
    <appinfo>
      <vocabulary>http://codes.wmo.int/49-2/SigConvectiveCloudType</vocabulary>
      <extensibility>none</extensibility>
  </appinfo>
  </annotation>
  <complexContent>
    <extension base="gml:ReferenceType"/>
  </complexContent>
</complexType>
<complexType name="CloudAmountReportedAtAerodromeType">
  <annotation>
    <appinfo>
      <vocabulary> http://codes.wmo.int/49-2/CloudAmountReportedAtAerodrome
      </vocabulary>
      <extensibility>none</extensibility>
    </appinfo>
  </annotation>
  <complexContent>
    <extension base="gml:ReferenceType"/>
  </complexContent>
</complexType>
```

Note that the complex type named CloudLayerType is defined as containing the following three elements: amount, base, and cloudType. Amount and cloud type are further defined as code lists with vocabularies. Base is a quantity, and that is defined too. (Note that the WMO Codes Registry, http://codes.wmo.int, is the source used to define both the quantity named base and the code lists for cloudType and amount. Later sections of the document will elaborate on the registry and its use.)

Here is a code fragment that shows an encoded example of cloudLayerType:

```
<om:result>
  <iwxxm:MeteorologicalAerodromeForecastRecord
    gml:id="base-fcst-record" cloudAndVisibilityOK="false">
    <iwxxm:cloud>
      <iwxxm:AerodromeCloudForecast gml:id="acf1">
         <iwxxm:layer>
          <iwxxm:CloudLayer>
            <iwxxm:amount
              xlink:href=http://codes.wmo.int/bufr4/codeflag/0-20-008/3
              xlink:title="Broken"/>
            <iwxxm:base uom="m">600</iwxxm:base>
          </iwxxm:CloudLayer>
        </iwxxm:layer>
      </iwxxm:AerodromeCloudForecast>
    </iwxxm:cloud>
  </iwxxm:MeteorologicalAerodromeForecastRecord>
</om:result>
```

Note that CloudLayer is encapsulated within layer, AerodromeCloudForecast, cloud, and MeteorologicalAerodromeForecastRecord.

4.4.3 An example of weak typing

The same cloud layer information could also be modelled using weak typing. We will illustrate this case by encoding the same broken cloud layer with a base of 600 meters using SWE Data Record.

```
<om:result xsi:type="swe:DataRecordPropertyType">
  <swe:DataRecord definition="record_weather.xml">
    <swe:field name="amount"
      <swe:Category definition=http://codes.wmo.int/bufr4/codeflag/0-20-008/>
        <swe:value>Broken</swe:value>
      </swe:Category>
    </swe:field>
    <swe:field name="base"
      <swe:Quantity
        definition=http://codes.wmo.int/common/quantity-kind/heightOfBaseOfCloud>
        <swe:uom xlink:href="m"/>
        <swe:value>600</swe:value>
      </swe:Quantity>
    </swe:field>
  </swe:DataRecord>
</om:result>
```

This example only shows the encoding, not a schema. That is because no schemas are explicitly required beyond the schemas defined for O&M and SWE Common. Om:result is of data type Any, so the XML shown will validate against the O&M schemas. Note that in this example the cloud amount and height of cloud base are both defined by making reference to the WMO Codes Registry.

4.5 Methods for generating data representations from UML

TT_AvXML spent a substantial level of effort developing a repeatable set of “mostly automated” procedures that successfully generated XML schemas from UML. These procedures were presented at the first meeting of the WMO’s Inter-Programme Expert Team on Metadata and Data Representation Development (IPET-MDRD) as Discussion Paper D24. A subsequent paper, D25, presented information on alternatives to these procedures which were still in development. Both papers can be downloaded from the IPET-MDRD web page at http://wis.wmo.int/page=IPET-MDRD-1. Discussion Paper D24 is included in its entirety here as Annex H. Both papers refer to the process as a “serialization procedure.”

5 THE WMO REGISTRY AND ITS USE

5.1 Overview of the WMO Registry

The WMO Codes Registry is the mechanism that publishes the authoritative terms required for WMO AvXML as web-accessible resources. This includes definitions of physical quantities as well as enumerating the values in code and flag tables.

The registry can be accessed at http://codes.wmo.int. This guide will focus on accessing the registry with a web browser using HyperText Transfer Protocol (HTTP). HTTP is the default response. The registry also supports Resource Description Framework (RDF) and Terse RDF Triple Language ("turtle"; TTL).

The WMO Codes Registry was originally implemented to support the exchange of aviation data in eXtensible Markup Language (XML; AvXML). AvXML was designed to use authoritative terms from WMO technical regulation – most notably Manual on Codes (WMO306) – as web-accessible resources.

The registry was originally populated with a small fraction of the entries in WMO306. The WMO plans to increase the number of entries, but this will take considerable time. Fortunately, strong naming conventions allow users to anticipate the Universal Resource Identified (URI) for an item before the registry actually supports it.

The registry has a search feature that allows users to search for entries throughout.

5.2 Parameter references and the WMO Registry

The WMO has defined a wealth of physical quantity kinds in its Table-Driven Code Forms (TDCF). Experts in the weather, water, and climate disciplines have maintained these code lists under strict governance for decades, and they continue to maintain them.

Those who wish to refer to the registry when encoding data will generally make appropriate notations in an XML schema. In the example below, a reference to the registry is encoded with a <quantity> element within the XML Schema <xs:appinfo>. This fragment is extracted from http://schemas.wmo.int/iwxxm/1.1/metarSpeci.xsd. Note the strong typing. The XML attribute airTemperature is explicitly defined.

```
<element name="airTemperature" type="gml:MeasureType">
  <annotation>
    <appinfo>
      <quantity>http://codes.wmo.int/common/quantity-kind/airTemperature</quantity>
    </appinfo>
  </annotation>
</element>
```

The WMO's Code Table D-2 "Physical quantity kinds" is supported within the registry at http://codes.wmo.int/common/quantity-kind. This table will support data encoding for a wide variety of weather elements. Other useful tables include BUFR4 Table B at http://codes.wmo.int/bufr4/b and GRIB2 Code and Flag tables at http://codes.wmo.int/grib2/codeflag.

5.3 Code lists and the WMO Registry

The WMO's TDCFs use a number of code and flag tables. These are also supported within the registry.

As with physical quantities above, those who wish to refer to these portions of the registry when encoding data will generally make appropriate notations in their XML schema. In the example below, a reference to a code table within the registry is encoded with a <vocabulary> element within the XML Schema <xs:appinfo>. (This fragment is also extracted from http://schemas.wmo.int/iwxxm/1.1/metarSpeci.xsd.)

```
<complexType name="RunwayDepositsType">
  <annotation>
    <appinfo>
      <vocabulary>http://codes.wmo.int/bufr4/codeflag/0-20-086</vocabulary>
      <extensibility>none</extensibility>
    </appinfo>
  </annotation>
  <complexContent>
    <extension base="gml:ReferenceType"/>
  </complexContent>
</complexType>
```

BUFR4 Code Table 0-20-086 is typically used to describe "What's on the runway?" at an aerodrome. Entries include "wet with water patches," "dry snow," "slush," "ice," and others.

Note that the URI encoded within the <vocabulary> element refers to BUFR4 Code Table 0-20-086 as a whole and not to a particular entry within that table. Note also the use of an <extensibility> element which can take on the values "narrower", "any", or "none". Extensibility of "none" implies only terms from the specified code list are permitted. Extensibility of "narrower" implies one may use terms with narrower semantics (some, but not all, of the items on the code list), and extensibility of "any" implies that the specified code list is simply a recommendation.

The WMO registry is typically also used to support encoding data in documents. The following XML code fragment indicates slush on the runway. (This fragment is extracted from http://schemas.wmo.int/examples/1.0/iwxxm/Example%20METAR%20(GML)%20LKKV%2020070725T12Z.xml.)

```
<iwxxm:runwayState>
  <iwxxm:AerodromeRunwayState>
    <iwxxm:depositType xlink:href="http://codes.wmo.int/bufr4/codeflag/0-20-086/1"
xlink:title="Damp"/>
  </iwxxm:AerodromeRunwayState>
</iwxxm:runwayState>
```

A user who follows the URL to the registry will find the description "damp" in multiple languages.

5.4 Regional Extensions to the WMO Registry

The WMO Registry can form the foundation of extended tables hosted by other entities. If an organization needed to use a portion of a table in the registry and add additional values, they would:

- Host the new table within their own resources~~.~~;
- Add the subset of desired entries as references to the WMO Registry;~~.~~
- Add additional entries hosted within their own resources.

6 REFERENCES

Fowler, M., 2004: *UML Distilled*. Third edition. Pearson Education, Incorporated, 175 pages.

ANNEX A: ABRIDGED CLASS DEFINITIONS AND CONTEXT DIAGRAMS FOR METCE

A.1 Introduction

The authoritative version of the METCE is maintained within AvXML as an online resource at the following URL: http://wis.wmo.int/AvXML/AvXML-1.1/index.htm. What follows is abridged to suit the needs of the print medium.

The Modèle pour l'Échange des Informations sur le Temps, le Climate et l'Éau (METCE) is a Logical Data Model (LDM) that supports the entire scope of WMO concerns: weather, climate and water. In English, it may also be known as the 'METeorological Community Exchange' model. The scope of METCE matches the WMO UN mandate, weather, climate, and water, and it complements existing WMO Table-Driven Code Forms (TDCF).

METCE is intended to provide conceptual definitions of meteorological phenomena, entities and concepts in order to underpin semantic interoperability in the weather, climate and water domains. The model includes the following three parts:

A data model for meteorological phenomena that contains a number of meteorological features (i.e., volcano and tropical cyclone)

A data model for observation and measurement types that contains specializations of OM_Observation, OM_ComplexObservation and OM_DiscreteCoverageObservation classes from ISO 19156

A data model for procedures that contains a concrete implementation of OM_Process from ISO 19156

A.2 Meteorological Phenomena

Notes: The package 'Meteorological Phenomena' contains «FeatureType» entities that have a significant role in meteorology; e.g. volcanoes and tropical cyclones.

A list of meteorological phenomena are provided in WMO No. 306 Vol I.2 FM 94 BUFR code-table 0 08 011 'Meteorological Feature' (see below). It is anticipated that in future releases the additional meteorological features listed therein will be incorporated.

A.2.1 EruptingVolcano

Type: Class.

Notes: A volcano that is currently erupting, or has recently erupted, that is the source of volcanic ash or other significant meteorological phenomena described in operational weather reports.

Attribute	***Multi-plicity***	***Type***	***Notes***
eruptionDate	[1]	DateTime	The date of eruption for the volcano.

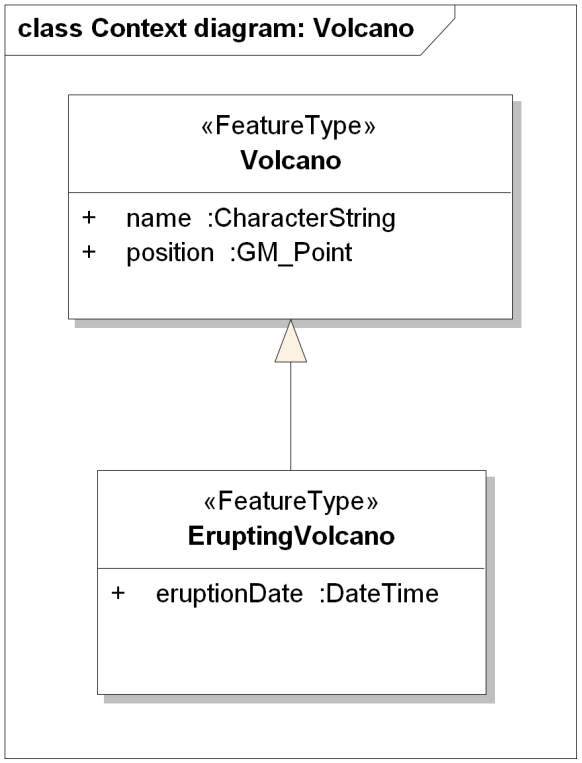
A.2.2 Volcano

Type: Class.

Notes: A volcano irrespective of the volcano's current state (e.g. passive or erupting).

Note that the "Global Volcanism Program" provides an online, searchable catalogue of volcanoes which may assist in identifying the authoritative name for a given volcano feature [http://www.volcano.si.edu/world/]. (informative)

Attribute	***Multi-plicity***	***Type***	***Notes***
name	[1]	CharacterString	The name of the volcano.
position	[1]	GM_Point	The position of the volcano.



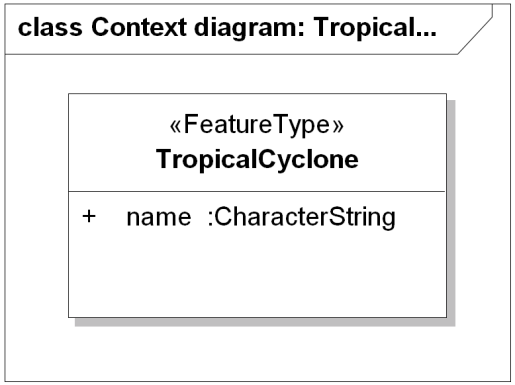
A.2.3 TropicalCyclone

Type: Class.

Notes: Cyclone of tropical origin of small diameter (some hundreds of kilometres) with minimum surface pressure in some cases less than 900 hPa, very violent winds and torrential rain; sometimes accompanied by thunderstorms. It usually contains a central region, known as the “eye” of the storm, with a diameter of the order of some tens of kilometres, and with light winds and more or less lightly clouded sky.

WMO No. 306 Vol I.1 code-table 3704 "Shape and definition of the eye of the tropical cyclone" and WMO No. 306 Vol I.1 code-table 3790 "Intensity of the tropical cyclone" provide additional candidate attributes that may be incorporated within this «FeatureType» in subsequent versions of METCE.

Attribute	*Multi-plicity*	*Type*	*Notes*
name	[1]	CharacterString	Name of tropical cyclone.



A.3 Observation and Measurement Types

Notes: ISO 19156 'Observations and measurements' provides a conceptual schema for observations and the features involved in sampling when making observations, and specifically designed to support the exchange of information describing both the observing event and the results of the observation between different scientific and technical communities.

Whilst the name of the model invokes a particular concept to meteorologists (e.g. 'observation', the measurement of physical phenomena with an instrument or sensor – disjoint from the concept of 'forecast') it is important to consider the semantics of the model. The class OM_Observation is defined as 'an estimate of the value of some property of some Thing using some specified Process'. The process may be an instrument/sensor (directly) measuring some physical parameter or a numerical simulation predicting future values. Thus the 'Observations and measurements' conceptual model may be used to represent both observations and forecasts.

Meteorological observations or forecasts clearly relate to the real world. For example, we may observe the weather for Exeter or provide a weather forecast for the 'North Atlantic European' area. However, there is a level of abstraction to resolve:

An observation of the weather for the city of Exeter happens at some representative location within the city or some representative locale nearby; or

The forecast domain for 'North Atlantic European' is specified so that it covers the areas for which a forecast is required

In each case, the ‘observation’ event relates to some sampling regime that is a proxy for the real entity of interest (e.g. the site of the weather station, or the extent of the forecast domain). The observation or forecast is not directly related to real-world entities.

ISO 19156 ‘Observations and measurements’ provides a conceptual model for describing this layer of indirection: Sampling Features. Further specialisations of Sampling Feature are provided based on spatial topology (SF_SpatialSamplingFeature and sub-types thereof).

In all cases identified thus far in meteorology, it appears useful to describe an observation, measurement or forecast with respect to the sampling regime (e.g. the Sampling Feature) and indirectly refer to the real-world entity for which the Sampling Feature is a proxy.

Spatial Sampling Features are considered an essential part of METCE: all observations, measurements and forecasts of meteorological phenomena shall define the ‘featureOfInterest’ as a concrete sub-type of SF_SpatialSamplingFeature.

Class 'OM_Process' (related to OM_Observation via the 'Procedure' Association) is used to define the process(es) involved in generating an observation. In order to ensure a consistent implementation of the abstract OM_Process class, *ALL* Application Schema based on METCE shall use the Process class defined therein (or sub-class thereof) to describe the observation procedure.

METCE provides three specialised types of OM_Observation; each of which enforce the constraints that 'featureOfInterest' shall refer to an entity of type SF_SpatialSamplingFeature (from ISO 19156), or subclass thereof, and 'procedure' shall refer to an entity of type Process (from METCE), or subclass thereof.

SamplingObservation: subclass of OM_Observation providing a general purpose observation type;

ComplexSamplingMeasurement: subclass of OM_ComplexObservation for use where the observation event is concerned with the evaluation of multiple measurands at a specified location and time instant or duration – the result of this observation type shall refer to an entity of type Record (from ISO 19103), or subclass thereof; and

SamplingCoverageMeasurement: subclass of OM_DiscreteCoverageObservation for use where the observation is concerned with the evaluation of measurands that vary with respect to space and/or time – the result of this observation type shall refer to an entity of type CV_DiscreteCoverage (from ISO 19123).

A.3.1 ComplexSamplingMeasurement

Type: Class.

Notes: Class ComplexSamplingMeasurement (a subclass of OM_ComplexObservation) is intended for use where the observation event is concerned with the evaluation of multiple measurands at a specified location and time instant or duration. The result of this observation type shall refer to an entity of metatype Record (from ISO 19103).

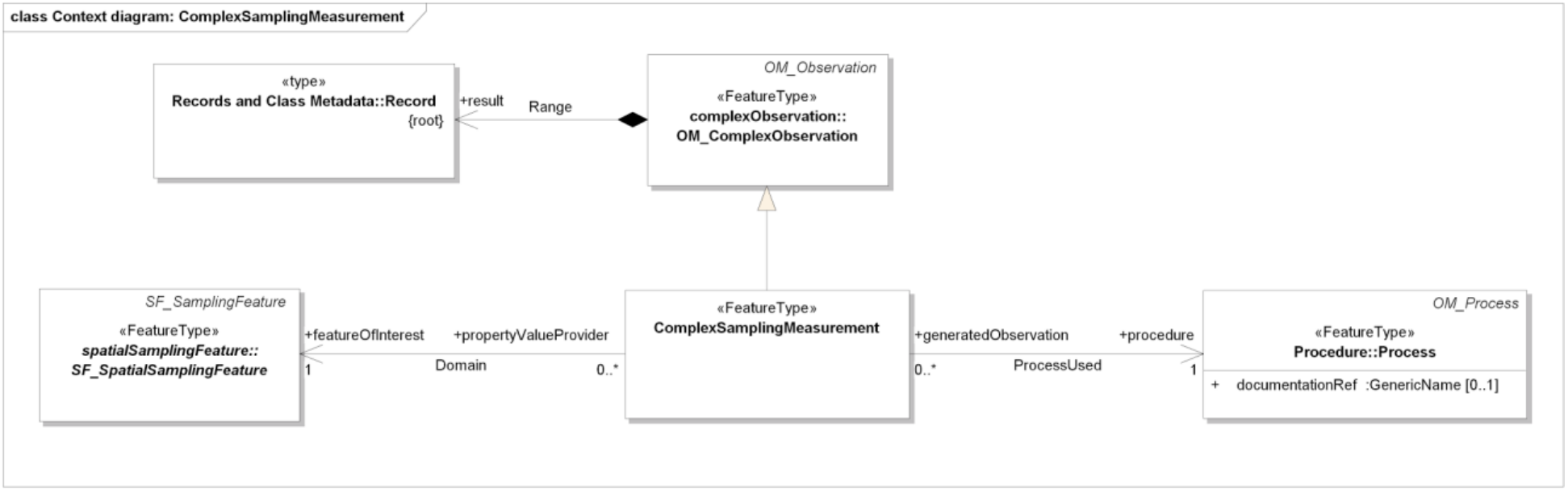
ComplexSamplingMeasurement enforces the following additional constraints:

'featureOfInterest' shall refer to an entity of type SF_SpatialSamplingFeature (from ISO 19156), or subclass thereof; and

'procedure' shall refer to an entity of type Process (from METCE), or subclass thereof

The OM_ComplexObservation is used because the 'result' of this class of observations is a group of measures, provided as a Record. Again, this matches the WMO application domain wherein multiple phenomena are measured within a single 'observation event'.

The term ‘measurement’ is used in the name in an attempt to reduce confusion arising from the overloading of the term ‘observation’.



A.3.2 SamplingCoverageMeasurement

Type: Class.

Notes: Class SamplingCoverageMeasurement (a subclass of OM_DiscreteCoverageObservation) is intended for use where the observation is concerned with the evaluation of measurands that vary with respect to space and/or time – the result of this observation type shall refer to an entity of type CV_DiscreteCoverage (from ISO 19123).

ComplexSamplingMeasurement enforces the following additional constraints:

'featureOfInterest' shall refer to an entity of type SF_SpatialSamplingFeature (from ISO 19156), or subclass thereof; and

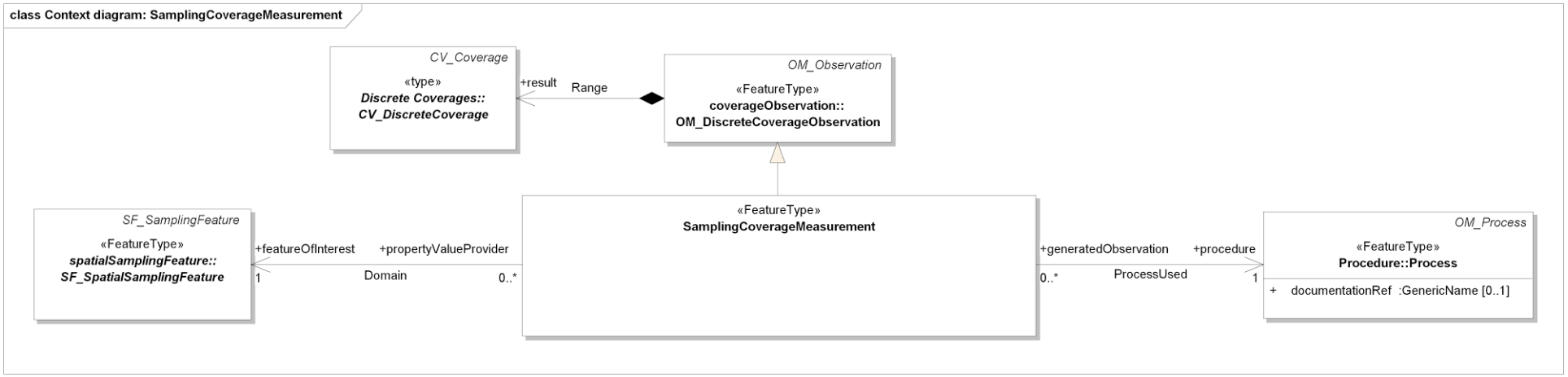
'procedure' shall refer to an entity of type Process (from METCE), or subclass thereof

A critical concern of meteorology is the understanding of the variation of physical phenomena with either space and/or time. This is exactly what the Coverage model is designed to convey.

Coverages are defined in 2 distinct categories: Discrete and Continuous. The main difference is that Continuous coverages provide an interpolation function to evaluate the phenomena at any point within the coverage domain, which Discrete coverages do not. A Discrete coverage is comprised of a number of domain elements (e.g. discrete locations where the phenomenon is sampled) and the associated range elements (e.g. the data). Where the phenomena are considered to be continuously varying within the Coverage domain, a user may apply their own interpolation algorithm as meets their specific requirement.

When describing properties that vary in space and/or time, METCE shall make exclusive use only of Discrete coverages.

The Class ‘SamplingCoverageMeasurement’ is based on the SamplingCoverageObservation which is defined in an informative annex of ISO 19156. However, the term ‘measurement’ is used in the name in an attempt to reduce confusion arising from the overloading of the term ‘observation’.



A.3.3 SamplingObservation

Type: Class.

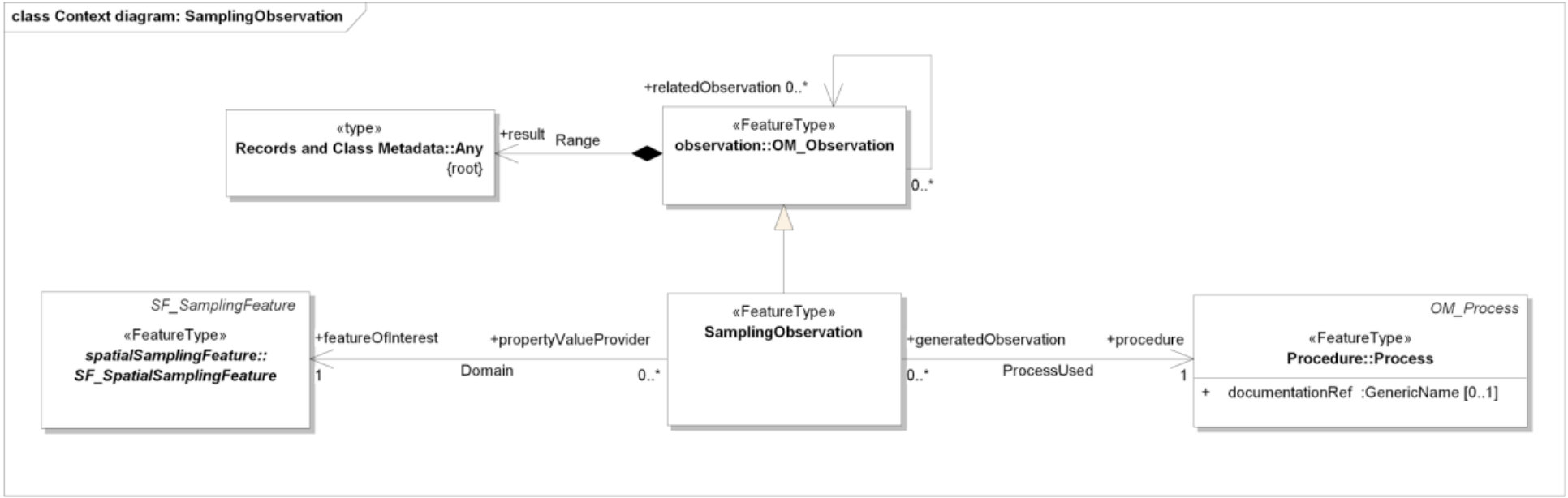
Notes: Class SamplingObservation (a subclass of OM_Observation) provides a general purpose observation type.

It enforces the following additional constraints:

'featureOfInterest' shall refer to an entity of type SF_SpatialSamplingFeature (from ISO 19156), or subclass thereof; and

'procedure' shall refer to an entity of type Process (from METCE), or subclass thereof

SamplingObservation is intended for use where measurement of physical phenomena is not the goal of the procedure. For example, the procedure executed to define SIGMET reports results in the identification of areas of turbulence, icing or other meteorological phenomena.



A.4 Procedure

Notes: The 'Procedure' package provides a concrete implementation of the abstract OM_Process class (from ISO 19156).

A.4.1 MeasurementContext

Type: Class.

Notes: Instances of the class 'MeasurementContext' specify the resolution [1] and measuring interval [2] for a given physical property in the context of this measurement procedure.

Attribute	***Multi-plicity***	***Type***	***Notes***
measurand	[1]	ObservableProperty	The attribute 'measurand' [1] specifies the physical property that the associated 'resolution' and 'measuring interval' apply to. The measurand may be sourced from an external controlled vocabulary, thesaurus or ontology or defined locally. The measurand may reference a qualified observable property if required. If the measurand references an observable physical property that serves as the base property for a qualified observable property, the measurement context is assumed to apply to ALL the qualified observable properties that reference this base property unless otherwise stated. For example, observable physical property 'radiance' may be qualified to measure wavelength bands 50-100nm, 100-200nm, 200-500nm etc. A measurement context associated with 'radiance' would be inferred to apply to all of these qualified radiance properties. [1] Measurand: quantity intended to be measured (from the 'International vocabulary of metrology' [http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2008.pdf]
measuringInterval	[0..1]	RangeBounds	The attribute 'measuringInterval' [1] specifies the extreme lower and upper limits of property values of the 'measurand' that can measured within this procedure, using the unit of measure 'uom'. [1] Measuring interval: set of values of quantities of the same kind that can be measured by a given measuring instrument or measuring system with specified instrumental uncertainty, under defined conditions (from the 'International vocabulary of metrology' [http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2008.pdf])

Attribute	***Multi-plicity***	***Type***	***Notes***
resolutionScale	[0..1]	Integer	The attribute 'resolutionScale' specifies the smallest change (e.g. the 'resolution' [1]) in property value of the 'measurand' that is intended to be measured within this procedure, using the unit of measure 'uom'. This shall be provided as a scaling factor. For example: scale = -2 implies a precision of 100 units scale = -1 implies a precision of 10 units scale = 0 implies a precision of 1 unit scale = 1 implies a precision of 0.1 units scale = 2 implies a precision of 0.01 units etc. [1] Resolution: smallest change in a quantity being measured that causes a perceptible change in the corresponding indication (from the 'International vocabulary of metrology' [http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2008.pdf])
unitOfMeasure	[0..1]	UnitOfMeasure	The attribute 'uom' specifies the unit of measure that the values of 'resolution' and 'measuring interval' are specified in. Typically, this will also be the unit of measure used to specify the measured quantity values. Unless otherwise specified, this unit of measure can be assumed to be the default unit of measure for this measurand.

A.4.2 Process

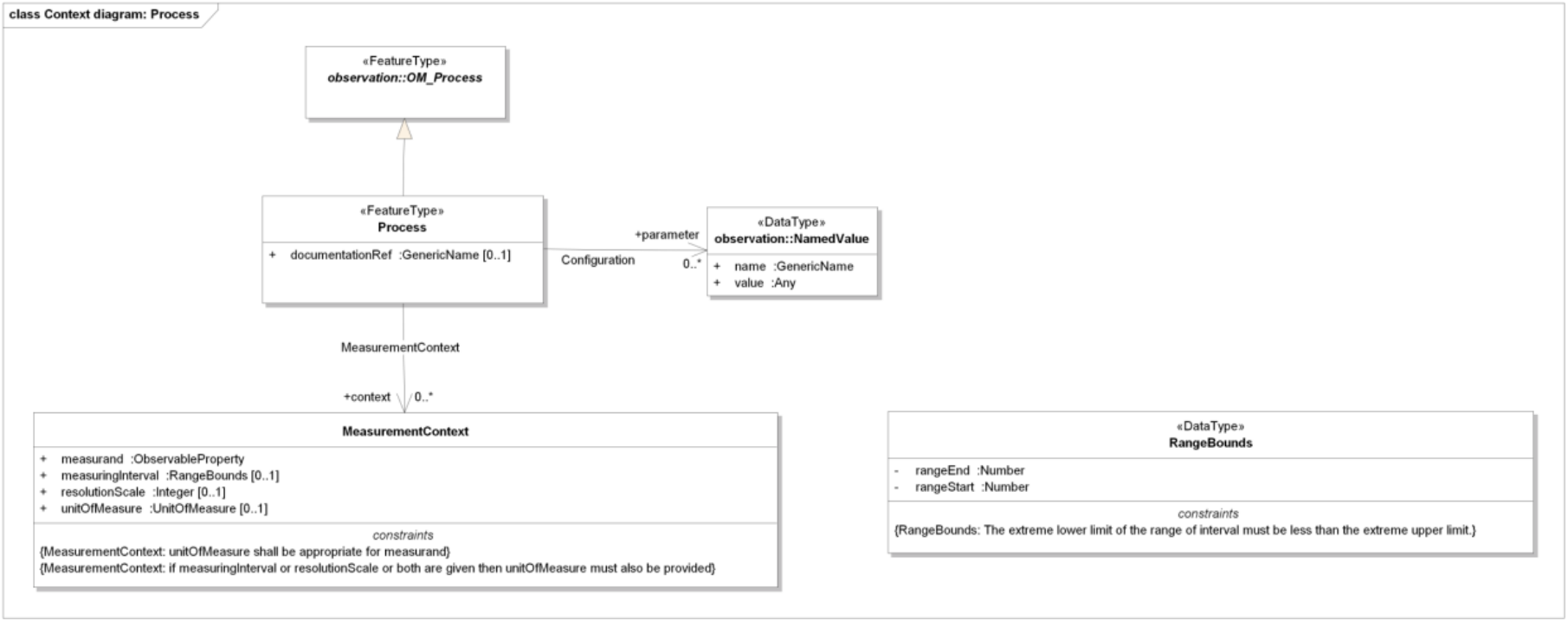
Type: Class.

Notes: Class 'OM_Process' (related to OM_Observation via the 'Procedure' Association) is used to define the process(es) involved in generating an observation. An instance of OM_Process is often an instrument or sensor (perhaps even a sensor in a given calibrated state), but it may be a human observer executing a set of instructions, a simulator or process algorithm. The 'Procedure' should provide sufficient information to interpret the result of an observation; thus if a sensor is recalibrated or its height above local ground is changed, a new instance of OM_Process should be created and associated with subsequent observations from that sensor (at least until the sensor is changed again).

Predominantly we expect the Process instance to be externally published / defined and 'static' (e.g. perhaps changing less often than once per month due to amendments to operational protocols etc.).

The class 'Process' provides a concrete implementation of OM_Process (from ISO 19156).

Attribute	***Multi-plicity***	***Type***	***Notes***
documentationRef	[0..1]	GenericName	Reference to an external process definition providing information about relevant documentation that describes the associated Process.



A.4.3 RangeBounds

Type: Class.

Notes: The class 'RangeBounds' describes the extreme limits of a property value range (also known as a property value interval).

Attribute	***Multi-plicity***	***Type***	***Notes***
rangeEnd	[1]	Number	The attribute 'rangeEnd' provides the extreme upper limit of the range or interval.
rangeStart	[1]	Number	The attribute 'rangeStart' provides the extreme lower limit of the range or interval.

ANNEX B: ABRIDGED CLASS DEFINITIONS AND CONTEXT DIAGRAMS FOR OBSERVABLE PROPERTIES MODEL (OPM)

B.1 Introduction

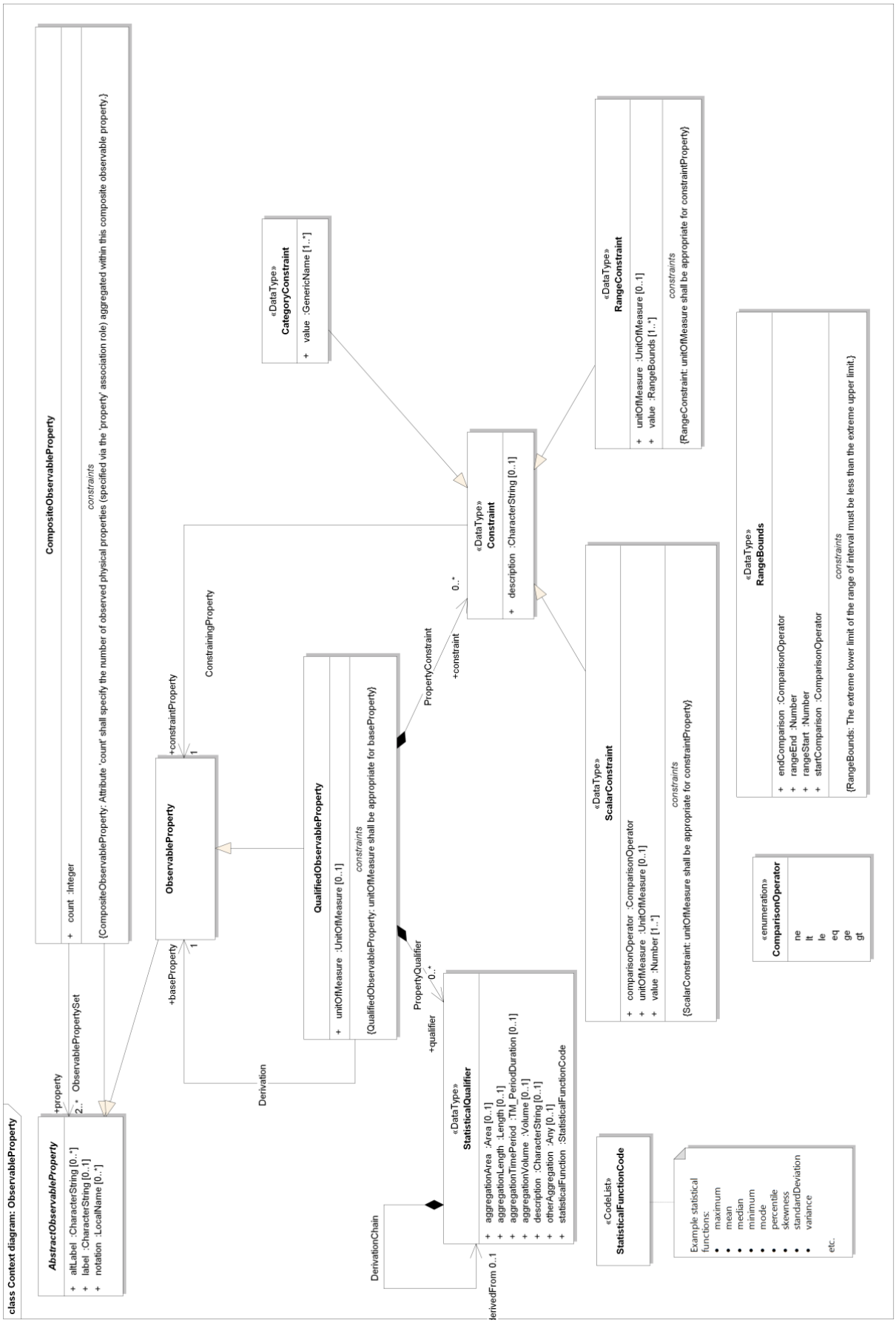
The authoritative version of the OPM is maintained within AvXML as an online resource at the following URL: http://wis.wmo.int/AvXML/AvXML-1.1/index.htm. What follows is abridged to suit the needs of the print medium.

The 'Observable Property' model enables observed physical properties to be aggregated into composite properties and for any qualification or constraint relating to those observed physical properties to be explicitly described.

A data publisher may need to use the Observed Property Model to explicitly define any qualification or constraint applied to the observed property, or, where the observation results in the evaluation of multiple properties, to explicitly define each of those individual physical properties.

B.2 Classes

The following context diagram shows the relationships among the various classes of OPM:


class Context diagram: ObservableProperty
CompositeObservableProperty
+ count :Integer
constraints
{CompositeObservableProperty: Attribute 'count' shall specify the number of observed physical properties (specified via the 'property' association role) aggregated within this composite observable property.}
AbstractObservableProperty
+ altLabel :CharacterString [0..*]
+ label :CharacterString [0..1]
+ notation :LocalName [0..*]
+property
2..*
ObservablePropertySet
+basePropertyProperty
1
1
ObservableProperty
+constraintProperty
1
ConstrainingProperty
Derivation
QualifiedObservableProperty
+ unitOfMeasure :UnitOfMeasure [0..1]
constraints
{QualifiedObservableProperty: unitOfMeasure shall be appropriate for baseProperty}
PropertyConstraint
+constraint
0..*
PropertyQualifier
0..*
+qualifier
«DataType»
StatisticalQualifier
+ aggregationArea :Area [0..1]
+ aggregationLength :Length [0..1]
+ aggregationTimePeriod :TM_PeriodDuration [0..1]
+ aggregationVolume :Volume [0..1]
+ description :CharacterString [0..1]
+ otherAggregation :Any [0..1]
+ statisticalFunction :StatisticalFunctionCode
DerivationChain
derivedFrom 0..1
«DataType»
Constraint
+ description :CharacterString [0..1]
«DataType»
CategoryConstraint
+ value :GenericName [1..*]
«DataType»
RangeConstraint
+ unitOfMeasure :UnitOfMeasure [0..1]
+ value :RangeBounds [1..*]
constraints
{RangeConstraint: unitOfMeasure shall be appropriate for constraintProperty}
«DataType»
ScalarConstraint
+ comparisonOperator :ComparisonOperator
+ unitOfMeasure :UnitOfMeasure [0..1]
+ value :Number [1..*]
constraints
{ScalarConstraint: unitOfMeasure shall be appropriate for constraintProperty}
«DataType»
RangeBounds
+ endComparison :ComparisonOperator
+ rangeEnd :Number
+ rangeStart :Number
+ startComparison :ComparisonOperator
constraints
{RangeBounds: The extreme lower limit of the range of interval must be less than the extreme upper limit.}
«enumeration»
ComparisonOperator
ne
lt
le
eq
ge
gt
«CodeList»
StatisticalFunctionCode
Example statistical functions:
• maximum
• mean
• median
• minimum
• mode
• percentile
• skewness
• standardDeviation
• variance
etc.

B.2.1 CompositeObservableProperty

Type: Class.

Notes: CompositeObservableProperty provides a single object within which a number of AbstractObservableProperty instances can be aggregated.

Attribute	***Multi-plicity***	***Type***	***Notes***
count	[1]	Integer	The number of observed physical properties aggregated within this composite.

B.2.2 AbstractObservableProperty

Type: Class.

Notes: An 'observable property' is a physical property that can be observed. Typically, this will be a quantitative property (Quantity [1]) such as 'dew-point temperature'.

This abstract class enables either a single physical property to be specified or a composite observable property that aggregates a set of physical properties for a given observation context.

In many cases, the observed physical property will be sourced from a controlled vocabulary, thesaurus or ontology.

[1] Quantity: property of a phenomenon, body, or substance, where the property has a magnitude that can be expressed as a number and a reference (from the 'International vocabulary of metrology' [http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2008.pdf])

Attribute	***Multi-plicity***	***Type***	***Notes***
altLabel	[0..*]	CharacterString	The attribute 'altLabel' provides an alternative human-readable label used to describe the physical property.
label	[0..1]	CharacterString	The attribute 'label' provides the primary human-readable label describing the observable physical property.
notation	[0..*]	LocalName	The attribute 'notation' provides a notation or code-value that is used to identify the physical property within a given context.

B.2.3 ObservableProperty

Type: Class.

Notes: An 'observable property' is a physical property that can be observed. Typically, this will be a quantitative property (Quantity [1]) such as 'dew-point temperature'.

In many cases, the observed physical property will be sourced from a controlled vocabulary, thesaurus or ontology. The definition may be a simple a SKOS Concept or a node in a well-defined ontology. As such, the attributes of ObservableProperty have been elided; we simply need to assert that the entity has compatible semantics with the ObservableProperty class defined herein.

[1] Quantity: property of a phenomenon, body, or substance, where the property has a magnitude that can be expressed as a number and a reference (from the 'International vocabulary of metrology' [http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2008.pdf])

B.2.4 QualifiedObservableProperty

Type: Class.

Notes: The class 'QualifiedObservableProperty' describes an observable physical property that is qualified or constrained within a given measurement context. Qualification of the observed physical property may take several forms:

- a specific unit of measure;

- a statistical operator (e.g. maximum) plus the aggregation context that the statistical operator applies to; or

- a constraint (e.g. radiance in wavelength band 50nm to 100nm).

Attribute	***Multi-plicity***	***Type***	***Notes***
unitOfMeasure	[0..1]	UnitOfMeasure	The attribute 'uom' specifies the unit of measure used in the measurement of this physical property.

B.2.5 StatisticalQualifier

Type: Class.

Notes: An observed physical property may be represent a statistical summary with respect to a base property; e.g. maximum UV index over a 3-hour period.

The class 'StatisticalQualifier' defines the type of statistical function plus the mechanism that is used to aggregate the base property values to create the statistical summary: length, area, volume, duration or other.

Statistical summary properties may be defined by chaining a set of statistical operations together. For example: mean daily maximum temperature over a month period comprises two statistical operations with respect to the base property 'air temperature' – (i) maximum over a 24-hour duration, (ii) mean over a 1-month duration.

Attribute	***Multi-plicity***	***Type***	***Notes***
aggregationArea	[0..1]	Area	The attribute 'aggregationArea' defines the spatial area over which the statistical function is applied in order to determine the statistical summary.
aggregationLength	[0..1]	Length	The attribute 'aggregationLength' defines the spatial length over which the statistical function is applied in order to determine the statistical summary.
aggregationTimePeriod	[0..1]	TM_PeriodDuration	The attribute 'aggregationTimePeriod' defines the temporal duration over which the statistical function is applied in order to determine the statistical summary.
aggregationVolume	[0..1]	Volume	The attribute 'aggregationVolume' defines the spatial volume over which the statistical function is applied in order to determine the statistical summary.
description	[0..1]	CharacterString	The attribute 'description' provides a textual description of the statistical qualification applied to the base observable physical property.
otherAggregation	[0..1]	Any	The attribute 'otherAggregation' defines the any type of aggregation (other than duration, length, area or volume) over which the statistical function is applied in order to determine the statistical summary; e.g. prevailing visibility is [approximately] defined as a mean visibility in each horizontal direction.
statisticalFunction	[1]	StatisticalFunctionCode	The attribute 'statisticalFunction' defines the type of statistical function that is applied to the base observed property values in order to generate the statistical summary.

B.2.6 Constraint

Type: Class.

Notes: The class 'Constraint' enables the constraints relating to an observable physical property in a given measurement context to be specified.

Attribute	***Multi-plicity***	***Type***	***Notes***
description	[0..1]	CharacterString	The attribute 'description' provides a textual description of the constraint applied to the base observable physical property.

B.2.7 CategoryConstraint

Type: Class.

Notes: The class 'CategoryConstraint' enables a category-based constraint to be specified. For example, in aviation the only clouds of significance for terminal aerodrome operations are convective clouds (cumulonimbus, towering cumulus etc.). The observed physical property 'cloud base [height]' may be constrained such that it is applicable only to clouds of a given type. In this example, a single instance of CategoryConstraint would be defined referencing both cloud types (cumulonimbus and towering cumulus); 'cloud type' is the constraint property.

Attribute	***Multi-plicity***	***Type***	***Notes***
value	[1..*]	GenericName	The attribute 'value' defines the category member that applies to this constraint.

B.2.8 ScalarConstraint

Type: Class.

Notes: The class 'ScalarConstraint' allows an observed physical property to be constrained according to specific values of the constraining property. For example, the base property 'air temperature' may be constrained such that we are concerned only with the air temperature at 2.0 metres above local ground level (e.g. a screen temperature). In this example, 'height above local ground level' is the constraint property.

Attribute	***Multi-plicity***	***Type***	***Notes***
comparisonOperator	[1]	ComparisonOperator	Attribute 'comparisonOperator' defines the mathematical operator relating the scalar constraint to the supplied numeric value; e.g. comparisonOperator = "eq" and value = "10.0" implies that the constraint is equal to the value 10.0.
unitOfMeasure	[0..1]	UnitOfMeasure	The attribute 'uom' specifies the unit of measure used in the specification of the constraint property value.
value	[1..*]	Number	The attribute 'value' provides the value of the constraint property.

B.2.9 RangeConstraint

Type: Class.

Notes: The class 'RangeConstraint' allows an observed physical property to be constrained according to a range of values of the constraining property. For example, the base property 'radiance' may be constrained such that we are concerned only with the radiance between wavelengths of 50nm to 100nm. In this example, 'wavelength' is the constraint property.

Attribute	***Multi-plicity***	***Type***	***Notes***
unitOfMeasure	[0..1]	UnitOfMeasure	The attribute 'uom' specifies the unit of measure used in the specification of the constraint property value.
value	[1..*]	RangeBounds	The association role 'value' references an instance of the RangeBounds class that specifies the extreme limits of the range that apply to the constraint property.

B.2.10 ComparisonOperator

Type: Enumeration.

Notes: «Enumeration» 'ComparisonOperator' defines the set mathematical operators that may be used to compare numerical values; not equal, less than, less than or equal, equal, greater than or equal and greater than.

Attribute	***Multi-plicity***	***Type***	***Notes***
ne	[1]		Comparison operator: "not equal to"
lt	[1]		Comparison operator: "less than"
le	[1]		Comparison operator: "less than or equal to"
eq	[1]		Comparison operator: "equal to"
ge	[1]		Comparison operator: "greater than or equal to"
gt	[1]		Comparison operator: "greater than"

B.2.11 RangeBounds

Type: Class.

Notes: The class 'RangeBounds' describes the extreme limits of a property value range (also known as a property value interval).

Attribute	***Multi-plicity***	***Type***	***Notes***
endComparison	[1]	ComparisonOperator	Attribute 'startComparison' defines the mathematical operator relating the lower boundary of the range constraint to the supplied numeric value; e.g. when specifying a wavelength band, startComparison = "eq", uom = "nm" and value = "100.0" implies that the lower range of the wavelength band is 100 nanometres.
rangeEnd	[1]	Number	The attribute 'rangeEnd' provides the extreme upper limit of the range or interval.
rangeStart	[1]	Number	The attribute 'rangeStart' provides the extreme lower limit of the range or interval.
startComparison	[1]	ComparisonOperator	Attribute 'startComparison' defines the mathematical operator relating the lower boundary of the range constraint to the supplied numeric value; e.g. when specifying a wavelength band, startComparison = "eq", uom = "nm" and value = "50.0" implies that the lower range of the wavelength band is 50 nanometres.

B.2.12 StatisticalFunctionCode

Type: Class.

Notes: The «CodeList» class 'StatisticalFunctionCode' specifies the type of statistical function that is applied to the base observable property to define the statistical summary; e.g. maximum air temperature.

Note that WMO provides two code-tables listing statistical operators:

- WMO No. 306 Vol I.2 Part B FM 92 GRIB code-table 4.10 'Type of statistical processing'; and

- WMO No. 306 Vol I.2 Part B FM 94 BUFR code-table 0 08 023 'First-order statistics'

The GRIB2 code-table is defined as the 'recommended' vocabulary for this «CodeList» class but lacks some of the necessary terms. For example, the GRIB code-table includes 'Average' but does not include 'Mean', 'Mode' or 'Median' (which can be found in the BUFR code-table). However, the BUFR code-table is _NOT_ chosen because 'Accumulation' is entirely missing. Given that 'extensibility' is set to 'any', authors are free to refer to their preferred 'statistical operator' vocabulary. The GRIB code-table is only a recommendation.

ANNEX C: ABRIDGED CLASS DEFINITIONS AND CONTEXT DIAGRAMS FOR SIMPLE AERONAUTICAL FEATURES (SAF)

C.1 Introduction

The authoritative version of the OPM is maintained within AvXML as an online resource at the following URL: http://wis.wmo.int/AvXML/AvXML-1.1/index.htm. What follows is abridged to suit the needs of the print medium.

The Simple Aeronautical Features model includes simplified features from the aeronautical domain, such as aerodrome, runway, unit, and airspace. These features are simplified representations of the more complex aeronautical features found in the Aeronautical Information Conceptual Model (AICM) and the Aeronautical Information eXchange Model (AIXM). They are simplified in SAF to facilitate both storage and transmission.

There are two independent issues involved in referencing aeronautical features: 1. Using AICM/AIXM classes directly for these concepts would introduce a dependency on AICM/AIXM, which is a package of significant size and complexity 2. Machine-readable, managed definitions for these concepts (such as the location, capabilities, and other information for the 'HTKJ' aerodrome) do not exist in a unified and authoritative form. This information is managed independently, and sometimes inconsistently, by many organizations worldwide.

The current version of this package is intended to address the needs for producers of meteorological information to be able to distribute the basic characteristics (identification, location, time, etc.) of their aeronautical information to consumers. In many cases data producers are the best authority for up-to-date aeronautical information. Downstream consumers may then use this information or ignore it. These concepts are represented in a way that is intended to be largely consistent with AICM/AIXM.

C.2 Features

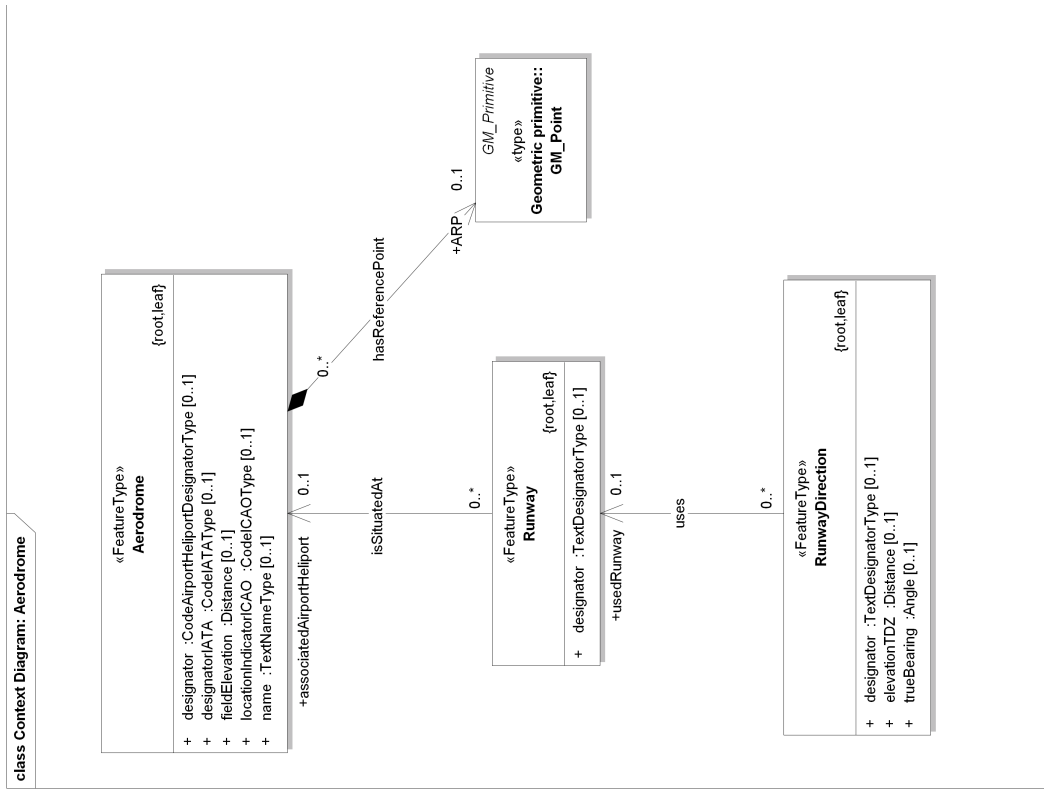
Notes: Package containing the definition of the core SAF Features. Features in this package roughly correspond to AIXM equivalents.

C.2.1 Aerodrome

Type: Class.

Notes: A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft/helicopters.

Attribute	***Multi-plicity***	***Type***	***Notes***
designator	[0..1]	CodeAirportHeliportDesignatorType	A coded designator for an Aerodrome/Heliport. The rules according to which this identifier should be formed are as follows: 1. If the AD/HP has an ICAO four letter location indicator, then this one will become the CODE_ID for the Aerodrome/Heliport; 2. If the AD/HP does not have an ICAO four letter location indicator, but it has an IATA three letter code, then this one will become the CODE_ID for the Aerodrome/Heliport; 3. If the AD/HP has neither an ICAO four letter location indicator nor an IATA three letter code, then an artificial generated code will be used. This will contain a group of letters and a number. The group of letters could be the 2 letter code of the State being responsible for the Aerodrome/Heliport and the number could be an integer between 0001 and 9999.
designatorIATA	[0..1]	CodeIATAType	The identifier that is assigned to a location in accordance with rules (resolution 767) governed by the International Air Transport Association (IATA).
fieldElevation	[0..1]	Distance	The vertical distance above Mean Sea Level (MSL) of the highest point of the landing area.
locationIndicatorICAO	[0..1]	CodeICAOType	The four letter ICAO location indicator of the aerodrome/heliport, as listed in ICAO DOC 7910.
name	[0..1]	TextNameType	The primary official name of an aerodrome as designated by an appropriate authority.

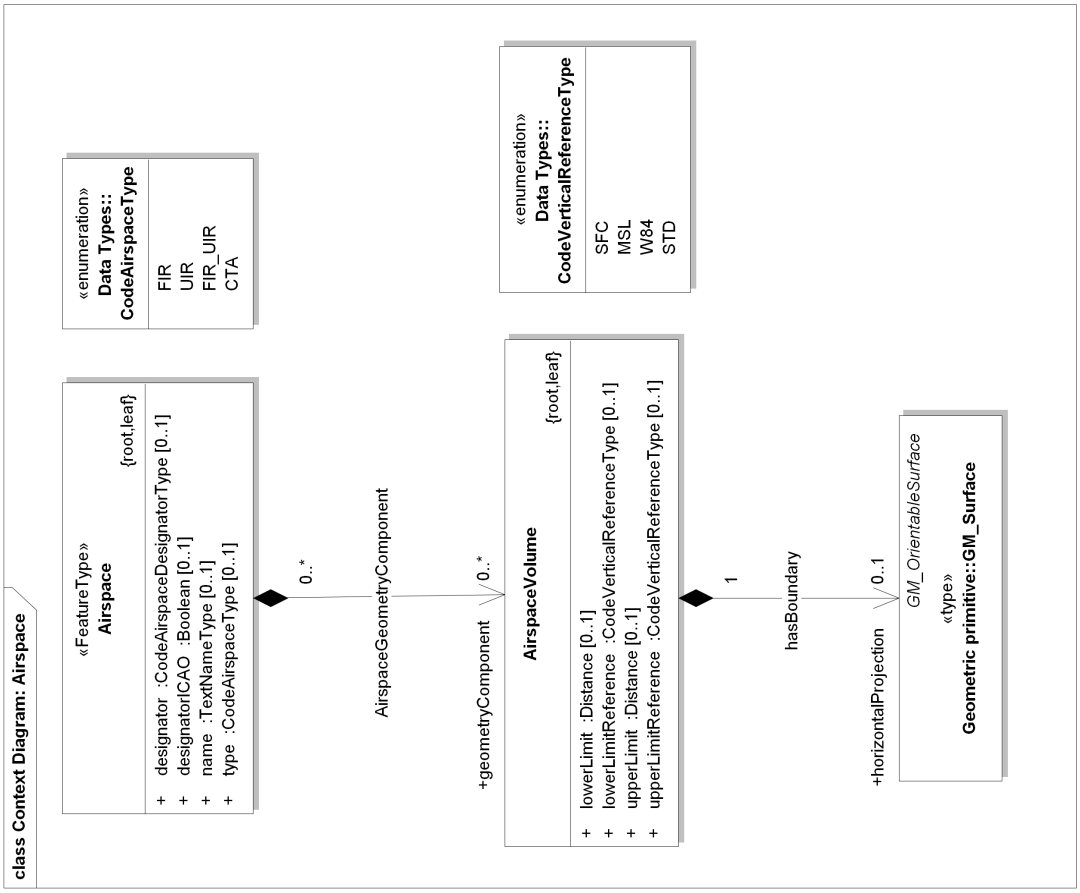

class Context Diagram: Aerodrome
«FeatureType»
Aerodrome
{root,leaf}
+ designator :CodeAirportHeliportDesignatorType [0..1]
+ designatorIATA :CodeIATAType [0..1]
+ fieldElevation :Distance [0..1]
+ locationIndicatorICAO :CodeICAOType [0..1]
+ name :TextNameType [0..1]
+associatedAirportHeliport
0..1
isSituatedAt
0..*
hasReferencePoint
0..*
+ARP
0..1
GM_Primitive
«type»
Geometric primitive::
GM_Point
«FeatureType»
Runway
{root,leaf}
+ designator :TextDesignatorType [0..1]
+usedRunway
0..1
uses
0..*
«FeatureType»
RunwayDirection
{root,leaf}
+ designator :TextDesignatorType [0..1]
+ elevationTDZ :Distance [0..1]
+ trueBearing :Angle [0..1]

C.2.2 Airspace

Type: Class.

Notes: A defined three dimensional region of space relevant to air traffic.

Attribute	***Multi-plicity***	***Type***	***Notes***
designator	[0..1]	CodeAirspaceDesignatorType	A published sequence of characters allowing the identification of the airspace. Description: Typical examples are the ID of the Danger, Prohibited, Temporary segregated Areas, etc.
designatorICAO	[0..1]	Boolean	A code indicating the Airspace designator is recorded in ICAO Doc. 7910.
name	[0..1]	TextNameType	The name given to an airspace by a responsible authority. Description: It should be written as published, with no significance to upper or lower case letters.
type	[0..1]	CodeAirspaceType	A code indicating the general structure or characteristics of a particular airspace.


class Context Diagram: Airspace
«FeatureType»
Airspace
{root,leaf}
+ designator :CodeAirspaceDesignatorType [0..1]
+ designatorICAO :Boolean [0..1]
+ name :TextNameType [0..1]
+ type :CodeAirspaceType [0..1]
«enumeration»
Data Types::
CodeAirspaceType
FIR
UIR
FIR_UIR
CTA
0..*
AirspaceGeometryComponent
+geometryComponent
0..*
AirspaceVolume
{root,leaf}
+ lowerLimit :Distance [0..1]
+ lowerLimitReference :CodeVerticalReferenceType [0..1]
+ upperLimit :Distance [0..1]
+ upperLimitReference :CodeVerticalReferenceType [0..1]
«enumeration»
Data Types::
CodeVerticalReferenceType
SFC
MSL
W84
STD
1
hasBoundary
+horizontalProjection
0..1
GM_OrientableSurface
«type»
Geometric primitive::GM_Surface

C.2.3 AirspaceVolume

Type: Class.

Notes: A defined volume in the air, described as horizontal projection with vertical limits.

Attribute	***Multi-plicity***	***Type***	***Notes***
lowerLimit	[0..1]	Distance	The vertical position of the airspace floor.
lowerLimitReference	[0..1]	CodeVerticalReferenceType	The reference surface used for the value of the lower limit. For example, Mean Sea Level, Ground, standard pressure, etc..
upperLimit	[0..1]	Distance	The vertical position of the airspace ceiling.
upperLimitReference	[0..1]	CodeVerticalReferenceType	The reference surface used for the value of the upper limit. For example, Mean Sea Level, Ground, standard pressure, etc..

C.2.4 Runway

Type: Class.

Notes: A defined rectangular area on a land aerodrome/heliport prepared for the landing and take-off of aircraft.

Note: this includes the concept of Final Approach and Take-Off Area (FATO) for helicopters.

Attribute	***Multi-plicity***	***Type***	***Notes***
designator	[0..1]	TextDesignatorType	The full textual designator of the runway, used to uniquely identify it at an aerodrome/heliport which has more than one. E.g. 09/27, 02R/20L, RWY 1.

C.2.5 RunwayDirection

Type: Class.

Notes: One of the two landing and take-off directions of a runway for which attributes like TORA, TODA, LDA, etc. may be defined.

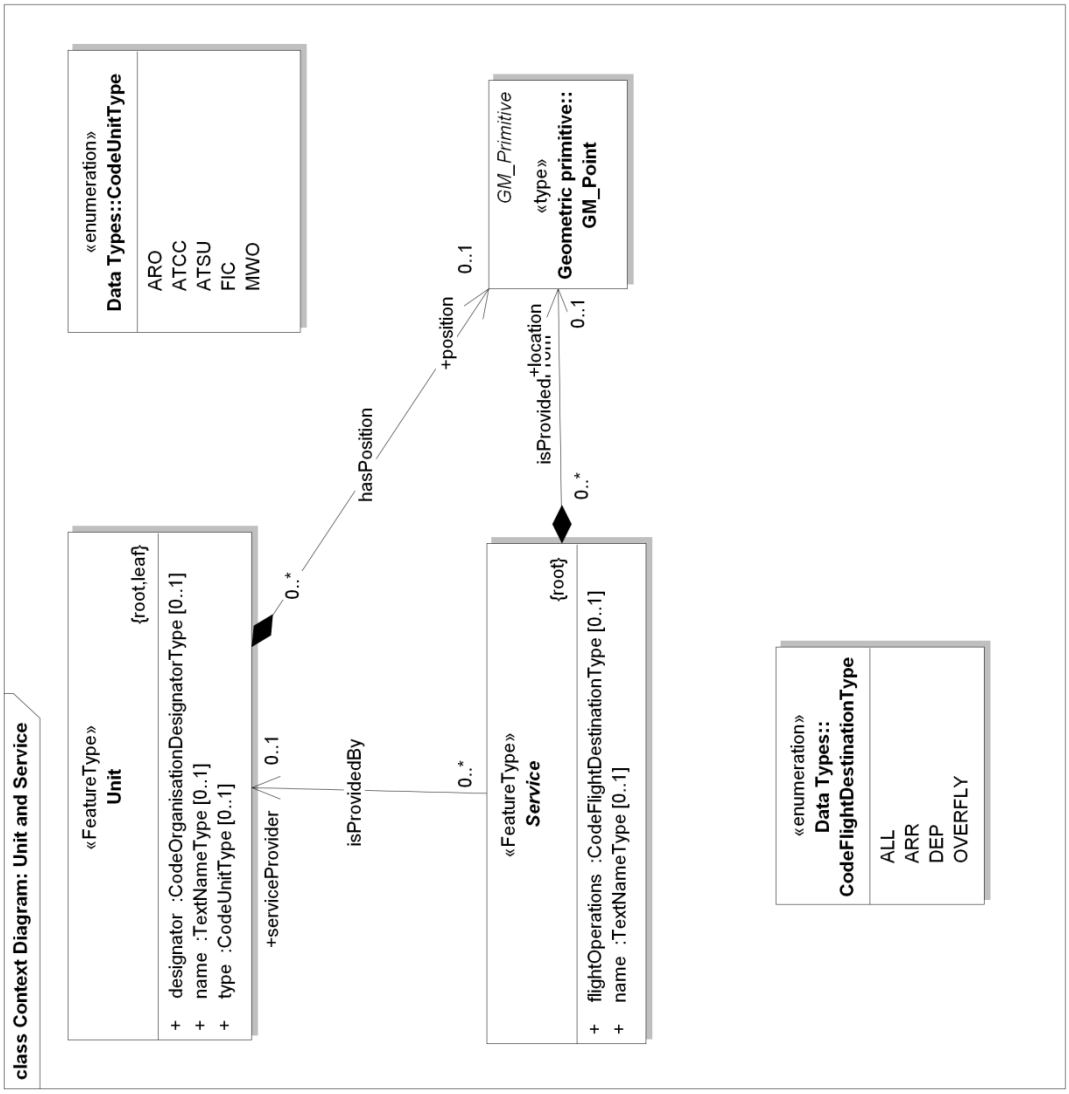
Attribute	***Multi-plicity***	***Type***	***Notes***
designator	[0..1]	TextDesignatorType	The full textual designator of the landing and take-off direction. Examples: 27, 35L, 01R.
elevationTDZ	[0..1]	Distance	Elevation of touch down zone: The value of the highest elevation of the runway Touch Down Zone (TDZ).
trueBearing	[0..1]	Angle	The measured angle between the runway direction and True North at a given position. Note : The True North is the north point at which the meridian lines meet.

C.2.6 Service

Type: Class.

Notes: The provision of tangible goods, information, instructions, guidance, etc. to pilots, flights, aircraft operators and other personnel and institutions concerned with flight operations.

Attribute	***Multi-plicity***	***Type***	***Notes***
flightOperations	[0..1]	CodeFlightDestinationType	The destination (arriving, departing, etc.) of the flights for which the information is provided.
name	[0..1]	TextNameType	A free text name by which the service is identified.


class Context Diagram: Unit and Service
«enumeration»
Data Types::CodeUnitType
ARO
ATCC
ATSU
FIC
MWO
«FeatureType»
Unit
{root,leaf}
+ designator :CodeOrganisationDesignatorType [0..1]
+ name :TextNameType [0..1]
+ type :CodeUnitType [0..1]
+serviceProvider
0..1
0..*
hasPosition
+position
0..1
GM_Primitive
«type»
Geometric primitive::
GM_Point
isProvided
+location
0..1
0..*
isProvidedBy
0..*
«FeatureType»
Service
{root}
+ flightOperations :CodeFlightDestinationType [0..1]
+ name :TextNameType [0..1]
«enumeration»
Data Types::
CodeFlightDestinationType
ALL
ARR
DEP
OVERFLY

C.2.7 Unit

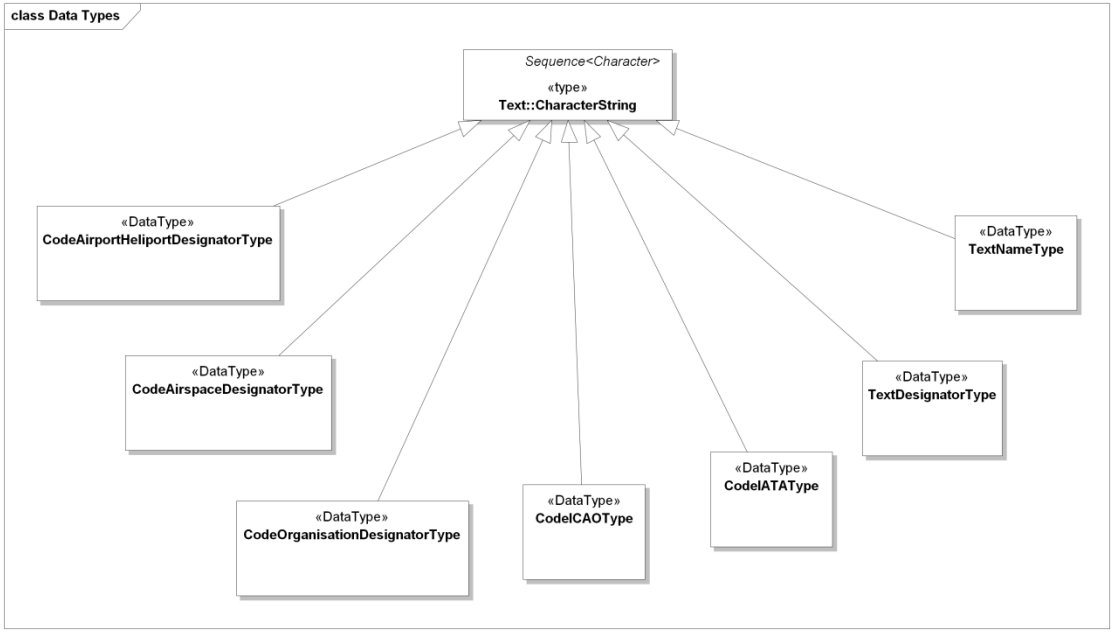
Type: Class.

Notes: A generic term meaning variously all types of 'units' providing all types of services. This includes particularly Air Traffic Management (ATM) Units but also units which are not express verbs included in ATM such as SAR, MET, COM etc.

Attribute	***Multi-plicity***	***Type***	***Notes***
designator	[0..1]	CodeOrganisationDesignatorType	A coded designator associated with the Unit. For example, the ICAO Location Indicator of an ACC, as listed in DOC 7910.
name	[0..1]	TextNameType	The full textual name of a unit. This name must be established according to the rules specified by ICAO, viz.: in the official language of the country, transposed into the Latin Alphabet where necessary.
type	[0..1]	CodeUnitType	A type by which the Unit is recognised, usually related to the standard type of services provided by it (e.g. area control centre, advisory centre, aeronautical information services office).

C.3 Data Types

Notes: Package containing the datatypes that are used throughout SAF. This is restricted set that are roughly analogous to equivalent AIXM data types.



C.3.1 CodeAirportHeliportDesignatorType

Type: Class.

Notes: A coded identifier for an Aerodrome/Heliport/Aerodrome.

The rules according to which this identifier should be formed are as follows:

1) If the AD/HP has an ICAO four letter location indicator, this will become the CODE_ID for the Aerodrome/Heliport;

2) If the AD/HP does not have an ICAO four letter location indicator but has an IATA three letter code, then this will become the CODE_ID for the Aerodrome/Heliport;

3) If the AD/HP does not have either an ICAO four letter location indicator or an IATA three letter code, an artificially generated code will be used. This will contain a group of letters and a number. The group of letters could be the 2 letter code of the State responsible for the Aerodrome/Heliport (or one of these, if there are more than one, like ED and ET for Germany) and the number could be an integer between 0001 and 9999.

C.3.2 CodeAirspaceDesignatorType

Type: Class.

Notes: A code indicating the general structure or characteristics of a particular airspace. This will generally include a published sequence of characters allowing the identification of the airspace. Typical examples are the ID of the Danger, Prohibited, Temporary segregated Areas, etc.

C.3.3 CodeAirspaceType

Type: Enumeration.

Notes: The valid codes that may be used for airspace type (e.g., flight information region, upper information region, controlled airspace).

Equivalent to AIXM CodeAirspaceType, except that only the codes of interest outside AIXM were used.

Attribute	***Multi-plicity***	***Type***	***Notes***
FIR	[1]		Flight information region. Airspace of defined dimensions within which flight information service and alerting service are provided. Description: ICAO Recognized. Might, for example, be used if service provided by more than one unit.
UIR	[1]		Upper flight information region. An upper airspace of defined dimensions within which flight information service and alerting service are provided. Description: Non-ICAO Recognized. Each state determines its definition for upper airspace.
FIR_UIR	[1]		Flight information region or upper flight information region.
CTA	[1]		Control area. A controlled airspace extending upwards from a specified limit above the earth. Description: ICAO Recognized.

C.3.4 CodeFlightDestinationType

Type: Enumeration.

Notes: A coded list of values that designate the intentions of a flight in relation with a location, such as arrival, departure or over-flight.

Attribute	***Multi-plicity***	***Type***	***Notes***
ALL	[1]		All types (arrival, departure and overflying).
ARR	[1]		Arrival flights.
DEP	[1]		Departing flights.
OVERFLY	[1]		Overflying flights.

C.3.5 CodeIATAType

Type: Class.

Notes: The three letter coded location identifier of an airport/heliport according to the IATA Resolution 763.

C.3.6 CodeICAOType

Type: Class.

Notes: The four letter coded location identifier as published in the ICAO DOC 7910 – Location Indicators.

C.3.7 CodeOrganisationDesignatorType

Type: Class.

Notes: The coded identifier of an organisation, authority, agency or unit.

C.3.8 CodeUnitType

Type: Enumeration.

Notes: A unit providing particular ATS services.

Attribute	***Multi-plicity***	***Type***	***Notes***
ARO	[1]		Aerodrome reporting office/ATS reporting office.
ATCC	[1]		Air traffic control centre.
ATSU	[1]		Air traffic services unit.
FIC	[1]		Flight information centre.
MWO	[1]		Meteorological watch office.

C.3.9 CodeVerticalReferenceType

Type: Enumeration.

Notes: The type of vertical reference (e.g., surface, mean sea level)

This class is copied from the AIXM class with the same name.

Attribute	***Multi-plicity***	***Type***	***Notes***
SFC	[1]		The distance measured from the surface of the Earth (equivalent to AGL – Above Ground Level).
MSL	[1]		The distance measured from mean sea level (equivalent to altitude).
W84	[1]		The distance measured from the WGS84 ellipsoid.
STD	[1]		The vertical distance is measured with an altimeter set to the standard atmosphere.

C.3.10 TextDesignatorType

Type: Class.

Notes: A textual designator.

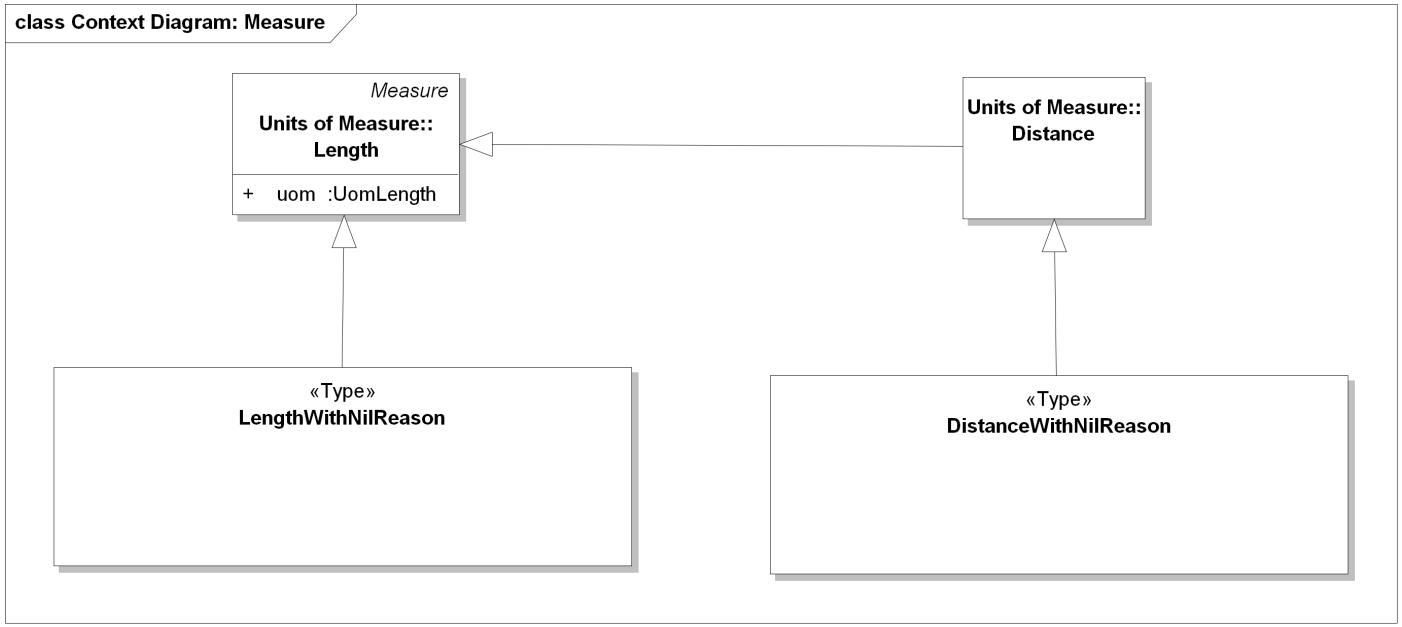
C.3.11 TextNameType

Type: Class.

Notes: The official name of a State, an aerodrome, a unit, etc..

C.4 Measures

Notes: Package with Nillable Measure and NilReason



C.4.1 DistanceWithNilReason

Type: Class.

Notes: A nillable Distance quantity. Unlike the base Distance measure, references to this type may be nil and may include a nilReason

C.4.2 LengthWithNilReason

Type: Class.

Notes: A nillable Length quantity. Unlike the base Length measure, references to this type may be nil and include a nilReason

ANNEX D: ABRIDGED CLASS DEFINITIONS AND CONTEXT DIAGRAMS FOR THE ICAO METEOROLOGICAL INFORMATION EXCHANGE MODEL (IWXXM), METAR AND SPECI

D.1 Introduction

The authoritative version of the OPM is maintained within AvXML as an online resource at the following URL:–http://wis.wmo.int/AvXML/AvXML-1.1/index.htm. What follows is abridged to suit the needs of the print medium.

D.2 The METAR and SPECI leaf of IWXXM

The METAR/SPECI leaf of the ICAO Meteorological Information Exchange Model (IWXXM) models the reporting constructs defined in ICAO Annex 3 / WMO No. 49-2.

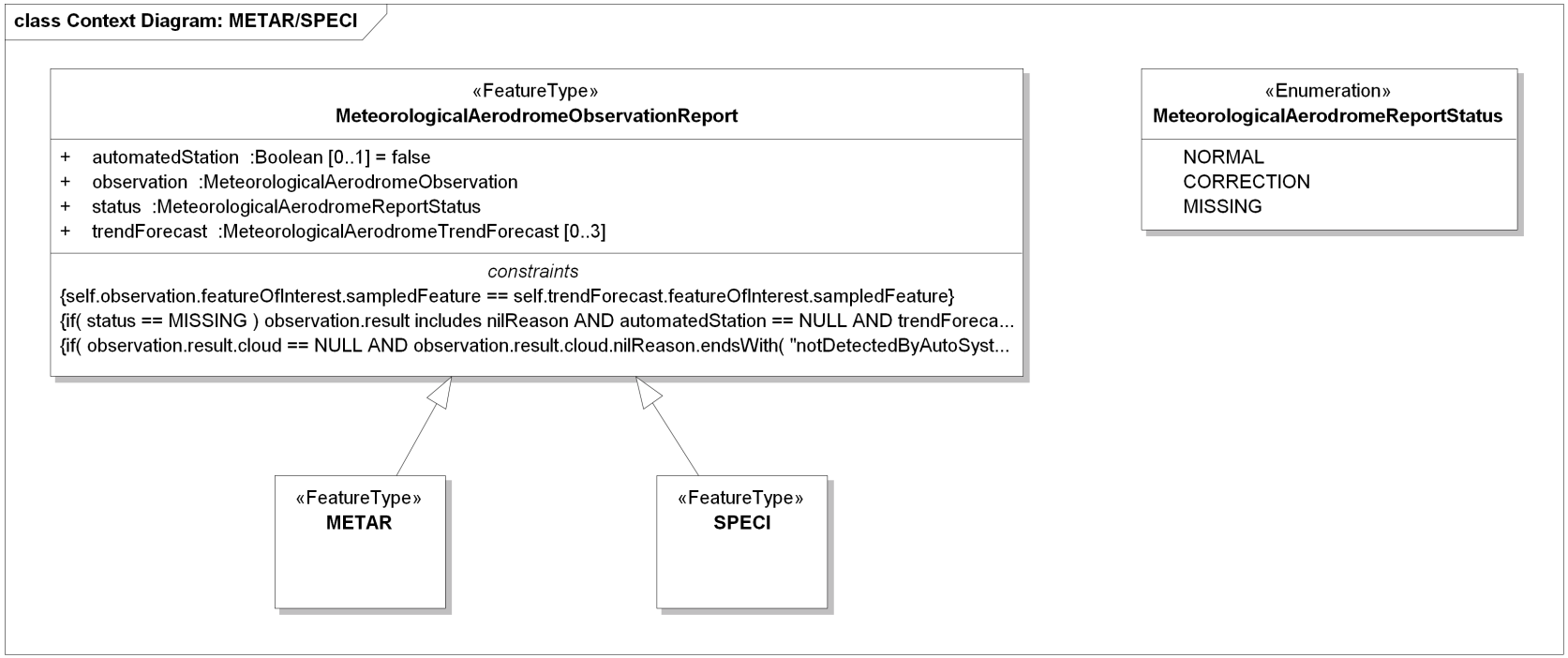
METAR and SPECI reports include identical information but are issued for different purposes. METAR reports are routine observations made at an aerodrome throughout the day. METAR observations are made (and distributed) at intervals of one hour or, if so determined by regional air navigation agreement, at intervals of one half-hour. SPECI reports are special (i.e., non-routine) observation made at an aerodrome as needed. SPECI observations are made (and distributed) in accordance with criteria established by the meteorological authority, in consultation with the appropriate ATS authority, operators and others concerned.

D.2.1 MeteorologicalAerodromeObservationReport

Type: Class.

Notes: A report of observed and trend forecast weather phenomenon from the surface near an aerodrome. This is a shared superclass for METAR and SPECI reports, which have identical reported information.

Attribute	***Multi-plicity***	***Type***	***Notes***
automatedStation	[0..1]	Boolean	When true, this report was reported by an automated station.
observation	[1]	MeteorologicalAerodromeObservation	The observation which resulted in the current meteorological conditions at an aerodrome
status	[1]	MeteorologicalAerodromeReportStatus	The report status (e.g., normal, corrected)
trendForecast	[0..3]	MeteorologicalAerodromeTrendForecast	The process that results in a trend forecast. When no change is expected to occur during a forecast period ("NOSIG") this is indicated by a single missing trend forecast with a nil reason of noSignificantChange



D.2.2 METAR

Type: Class.

Notes: A routine observation made at an aerodrome throughout the day. METAR observations are made (and distributed) at intervals of one hour or, if so determined by regional air navigation agreement, at intervals of one half-hour.

The information contained in METAR and SPECI is identical. SPECI is issued when conditions merit a non-routine report on conditions at an aerodrome.

METARs are a routine report produced for dissemination beyond the aerodrome of origin, and are mainly intended for flight planning, VOLMET broadcasts and D-VOLMET.

See ICAO Annex 3 / WMO No. 49-2 Table A3-2

D.2.3 SPECI

Type: Class.

Notes: A special (i.e., non-routine) observation made at an aerodrome as needed. SPECI observations are made (and distributed) in accordance with criteria established by the meteorological authority, in consultation with the appropriate ATS authority, operators and others concerned.

The information contained in METAR and SPECI is identical. SPECI is issued when conditions merit a non-routine report on conditions at an aerodrome.

SPECI reports are used for dissemination beyond the aerodrome of origin (mainly intended for flight planning, VOLMET broadcasts and D-VOLMET) unless METAR are issued at half-hourly intervals.

SPECI is issued following the resumption of the issuance of METAR, as necessary, at aerodromes that are not operational throughout 24 hours in accordance with ICAO Annex 3 Section 4.3.1.

See ICAO Annex 3 / WMO No. 49-2 Table A3-2

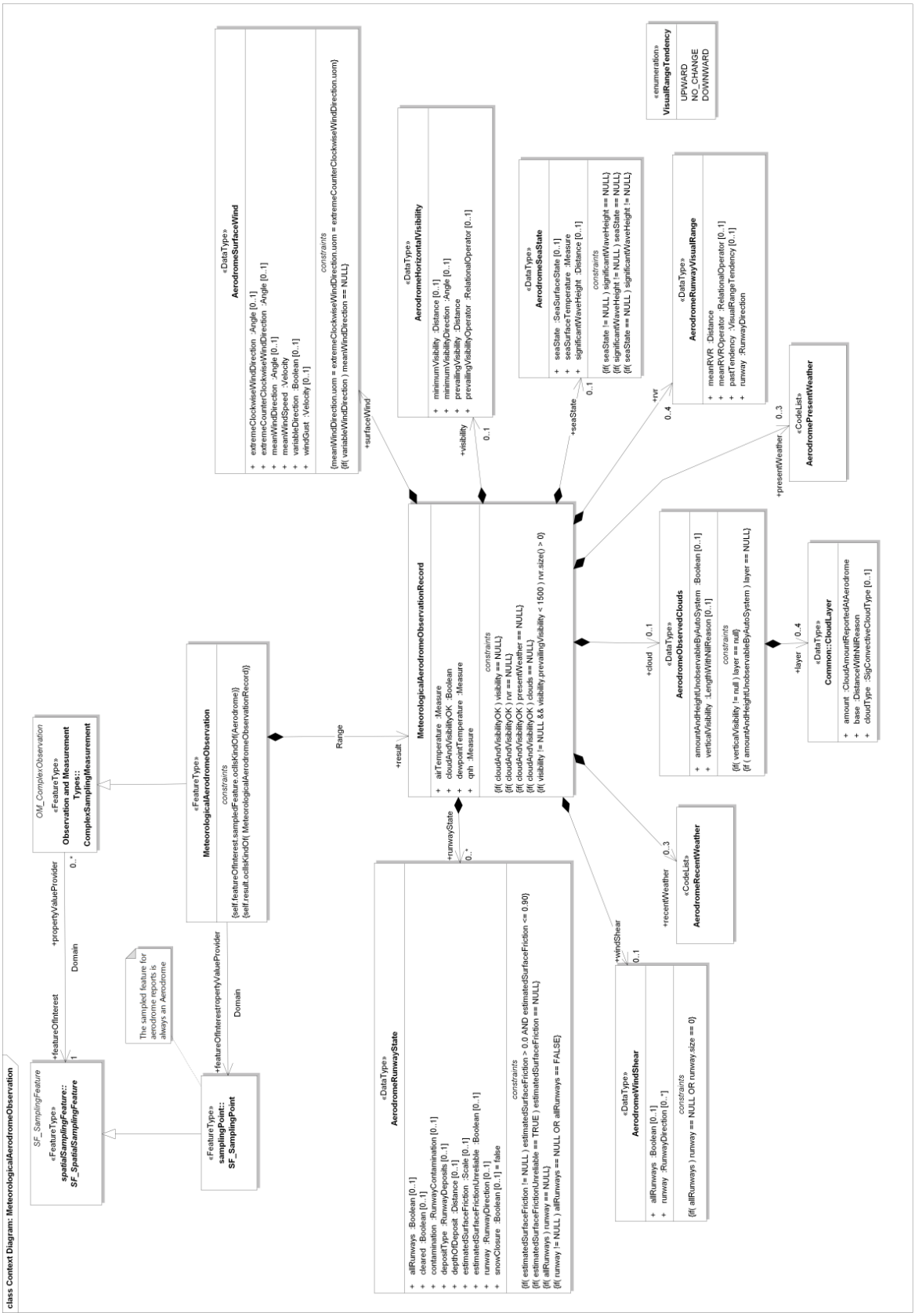
D.2.4 MeteorologicalAerodromeObservation

Type: Class.

Notes: A specialized OM_Observation type used for reporting an aggregate set of observed meteorological conditions at an Aerodrome. The result of this observation type refers to an entity of type MeteorologicalAerodromeObservationRecord.

ComplexSamplingMeasurement enforces the sampled feature be an Aerodrome.

MeteorologicalAerodromeObservation has a sister Class for forecast information at an Aerodrome: MeteorologicalAerodromeTrendForecast.


class Context Diagram: MeteorologicalAerodromeObservation
OM_ComplexObservation
«FeatureType»
Observation and Measurement Types::
ComplexSamplingMeasurement
SF_SamplingFeature
«FeatureType»
spatialSamplingFeature::
SF_SpatialSamplingFeature
+featureOfInterest
1
+propertyValueProvider
0..*
Domain
The sampled feature for aerodrome reports is always an Aerodrome
«FeatureType»
samplingPoint::
SF_SamplingPoint
+featureOfInterestpropertyValueProvider
Domain
«FeatureType»
MeteorologicalAerodromeObservation
constraints
{self.featureOfInterest.sampledFeature.oclIsKindOf(Aerodrome)}
{self.result.oclIsKindOf(MeteorologicalAerodromeObservationRecord)}
Range
+result
MeteorologicalAerodromeObservationRecord
+ airTemperature :Measure
+ cloudAndVisibilityOK :Boolean
+ dewpointTemperature :Measure
+ qnh :Measure
constraints
{if(cloudAndVisibilityOK) visibility == NULL}
{if(cloudAndVisibilityOK) rvr == NULL}
{if(cloudAndVisibilityOK) presentWeather == NULL}
{if(cloudAndVisibilityOK) clouds == NULL}
{if(visibility != NULL && visibility.prevailingVisibility < 1500) rvr.size() > 0}
+runwayState
0..*
«DataType»
AerodromeRunwayState
+ allRunways :Boolean [0..1]
+ cleared :Boolean [0..1]
+ contamination :RunwayContamination [0..1]
+ depositType :RunwayDeposits [0..1]
+ depthOfDeposit :Distance [0..1]
+ estimatedSurfaceFriction :Scale [0..1]
+ estimatedSurfaceFrictionUnreliable :Boolean [0..1]
+ runway :RunwayDirection [0..1]
+ snowClosure :Boolean [0..1] = false
constraints
{if(estimatedSurfaceFriction != NULL) estimatedSurfaceFriction > 0.0 AND estimatedSurfaceFriction <= 0.90}
{if(estimatedSurfaceFrictionUnreliable == TRUE) estimatedSurfaceFriction == NULL}
{if(allRunways) runway == NULL}
{if(runway != NULL) allRunways == NULL OR allRunways == FALSE}
+windShear
0..1
«DataType»
AerodromeWindShear
+ allRunways :Boolean [0..1]
+ runway :RunwayDirection [0..*]
constraints
{if(allRunways) runway == NULL OR runway.size == 0}
+recentWeather
0..3
«CodeList»
AerodromeRecentWeather
+cloud
0..1
«DataTypes»
AerodromeObservedClouds
+ amountAndHeightUnobservableByAutoSystem :Boolean [0..1]
+ verticalVisibility :LengthWithNilReason [0..1]
constraints
{if(verticalVisibility != null) layer == null}
{if (amountAndHeightUnobservableByAutoSystem) layer == NULL}
+layer
0..4
«DataType»
Common::CloudLayer
+ amount :CloudAmountReportedAtAerodrome
+ base :DistanceWithNilReason
+ cloudType :SigConvectiveCloudType [0..1]
+visibility
0..1
«DataType»
AerodromeHorizontalVisibility
+ minimumVisibility :Distance [0..1]
+ minimumVisibilityDirection :Angle [0..1]
+ prevailingVisibility :Distance
+ prevailingVisibilityOperator :RelationalOperator [0..1]
+seaState
0..1
«DataTypes»
AerodromeSeaState
+ seaState :SeaSurfaceState [0..1]
+ seaSurfaceTemperature :Measure
+ significantWaveHeight :Distance [0..1]
constraints
{if(seaState != NULL) significantWaveHeight == NULL}
{if(significantWaveHeight != NULL) seaState == NULL}
{if(seaState == NULL) significantWaveHeight != NULL}
+surfaceWind
«DataType»
AerodromeSurfaceWind
+ extremeClockwiseWindDirection :Angle [0..1]
+ extremeCounterClockwiseWindDirection :Angle [0..1]
+ meanWindDirection :Angle [0..1]
+ meanWindSpeed :Velocity
+ variableDirection :Boolean [0..1]
+ windGust :Velocity [0..1]
constraints
{meanWindDirection.uom = extremeClockwiseWindDirection.uom = extremeCounterClockwiseWindDirection.uom}
{if(variableWindDirection) meanWindDirection == NULL}
+rvr
0..4
«DataTypes»
AerodromeRunwayVisualRange
+ meanRVR :Distance
+ meanRVROperator :RelationalOperator [0..1]
+ pastTendency :VisualRangeTendency [0..1]
+ runway :RunwayDirection
«enumeration»
VisualRangeTendency
UPWARD
NO_CHANGE
DOWNWARD
+presentWeather
0..3
«CodeLists»
AerodromePresentWeather

D.2.5 MeteorologicalAerodromeObservationRecord

Type: Class.

Notes: A specialized Record type containing meteorological conditions observed at an aerodrome.

When no clouds of operational significance or no weather of operational significance is observed, the NothingOfOperationalSignificance nilReason is used for the cloud or presentWeather association. When no clouds were detected by the automatic observing system, the NotDetectedByAutoSystem nilReason is used for the cloud association.

Attribute	***Multi-plicity***	***Type***	***Notes***
airTemperature	[1]	Measure	The observed air temperature. This is the temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation.
cloudAndVisibilityOK	[1]	Boolean	When true, indicates that the observed cloud ceiling, horizontal visibility, and weather conditions are of no operational significance. See ICAO Annex 3 / WMO No. 49-2 Section 2.2. Also known as "CAVOK" When CAVOK conditions are observed, no other information on visibility, runway visual range, present weather, cloud amount, or cloud type is reported
dewpointTemperature	[1]	Measure	The observed dew point temperature. This is the temperature to which a given air parcel must be cooled at constant pressure and constant water vapour content in order for saturation to occur.
qnh	[1]	Measure	The observed QNH altimeter setting. Altitude setting (also known as QNH) is defined as barometric pressure adjusted to sea level. It is a pressure setting used by pilots, air traffic control (ATC), and low frequency weather beacons to refer to the barometric setting which, when set on an aircraft's altimeter, will cause the altimeter to read altitude above mean sea level within a certain defined region.

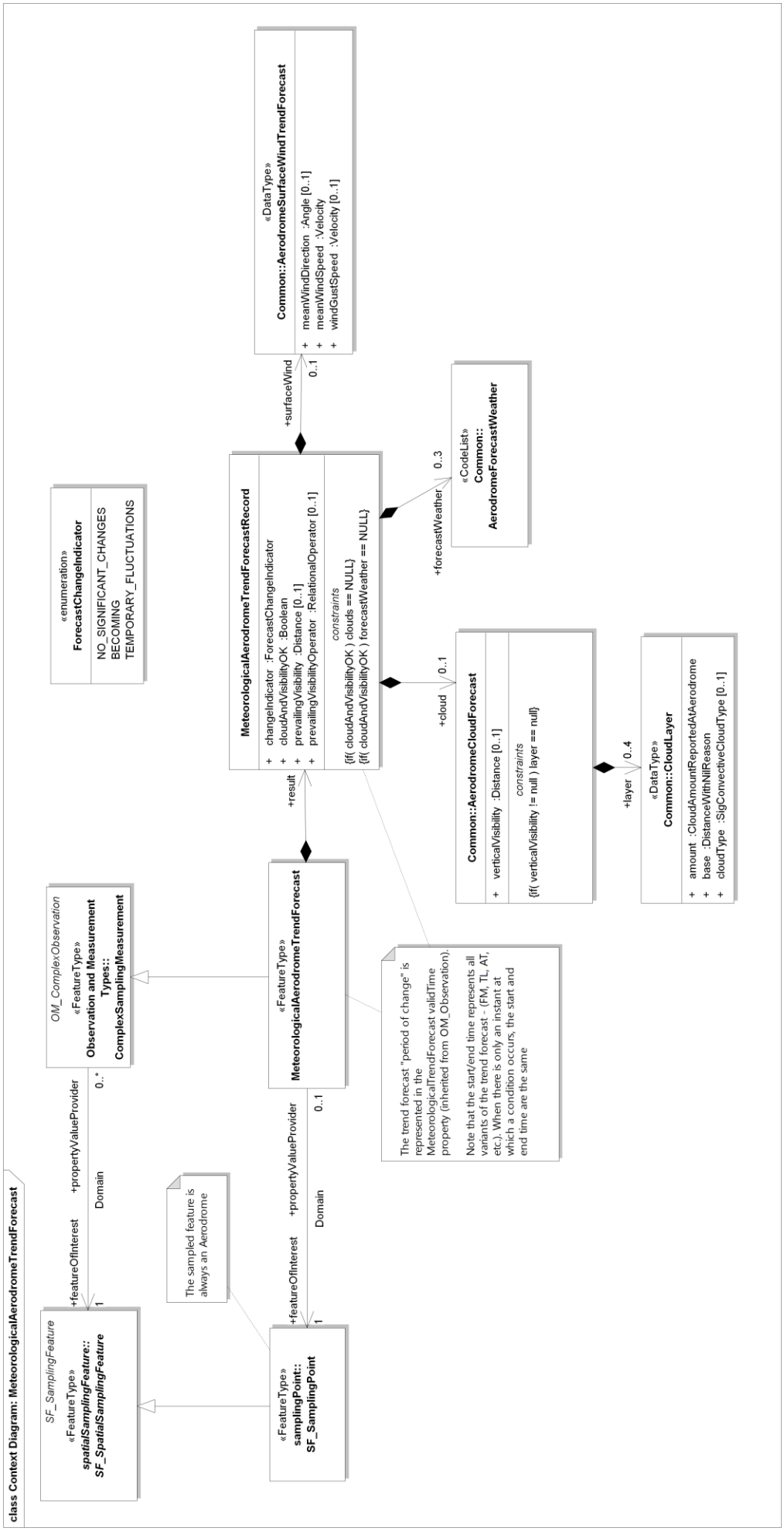
D.2.6 MeteorologicalAerodromeTrendForecast

Type: Class.

Notes: A specialized OM_Observation type used for reporting an aggregate set of forecast meteorological conditions at an Aerodrome. The result of this observation type refers to an entity of type MeteorologicalAerodromeTrendForecastRecord.

MeteorologicalAerodromeTrendForecast additionally enforces that the sampled feature must be an Aerodrome

MeteorologicalAerodromeTrendForecasts are reported in surface observation reports such as SPECI and METAR. MeteorologicalAerodromeTrendForecast has a sister class for trend forecast information at an Aerodrome (MeteorologicalAerodromeObservation) which is also reported on a METAR and SPECI for observed phenomena. This class is also related but not identical to MeteorologicalAerodromeForecast which is reported on a TAF – conditions reported in trend forecasts in METAR/SPECI differ from forecast groups in a TAF.


class Context Diagram: MeteorologicalAerodromeTrendForecast
«DataType»
Common::AerodromeSurfaceWindTrendForecast
+ meanWindDirection :Angle [0..1]
+ meanWindSpeed :Velocity
+ windGustSpeed :Velocity [0..1]
+surfaceWind
0..1
«CodeList»
Common::
AerodromeForecastWeather
0..3
+forecastWeather
«enumeration»
ForecastChangeIndicator
NO_SIGNIFICANT_CHANGES
BECOMING
TEMPORARY_FLUCTUATIONS
MeteorologicalAerodromeTrendForecastRecord
+ changeIndicator :ForecastChangeIndicator
+ cloudAndVisibilityOK :Boolean
+ prevailingVisibility :Distance [0..1]
+ prevailingVisibilityOperator :RelationalOperator [0..1]
constraints
{if(cloudAndVisibilityOK) clouds == NULL}
{if(cloudAndVisibilityOK) forecastWeather == NULL}
+cloud
0..1
Common::AerodromeCloudForecast
+ verticalVisibility :Distance [0..1]
constraints
{if(verticalVisibility != null) layer == null}
+layer
0..4
«DataType»
Common::CloudLayer
+ amount :CloudAmountReportedAtAerodrome
+ base :DistanceWithNilReason
+ cloudType :SigConvectiveCloudType [0..1]
+result
OM_ComplexObservation
«FeatureType»
Observation and Measurement
Types::
ComplexSamplingMeasurement
«FeatureType»
MeteorologicalAerodromeTrendForecast
The trend forecast "period of change" is represented in the MeteorologicalTrendForecast validTime property (inherited from OM_Observation).
Note that the start/end time represents all variants of the trend forecast - (FM, TL, AT, etc.). When there is only an instant at which a condition occurs, the start and end time are the same
+propertyValueProvider
0..*
Domain
+featureOfInterest
1
+propertyValueProvider
0..1
Domain
+featureOfInterest
1
The sampled feature is always an Aerodrome
SF_SamplingFeature
«FeatureType»
spatialSamplingFeature::
SF_SpatialSamplingFeature
«FeatureType»
samplingPoint::
SF_SamplingPoint

D.2.7 MeteorologicalAerodromeTrendForecastRecord

Type: Class.

Notes: A specialized Record type containing meteorological conditions for trend forecasting at an aerodrome. This class is also related but not identical to MeteorologicalAerodromeForecastRecord which is reported on a TAF – conditions reported in trend forecasts in METAR/SPECI differ from forecast groups in a TAF.

When no clouds of operational significance or no weather of operational significance is predicted, the NothingOfOperationalSignificance nilReason should be used for the cloud or presentWeather association. When no clouds were detected by the automatic observing system, the NotDetectedByAutoSystem nilReason should be used for the cloud association.

Attribute	***Multi-plicity***	***Type***	***Notes***
changeIndicator	[1]	ForecastChangeIndicator	The change indicator for this trend forecast – becoming, temporary conditions, or no significant change
cloudAndVisibilityOK	[1]	Boolean	When true, indicates that the observed cloud ceiling, horizontal visibility, and weather conditions are of no operational significance. See ICAO Annex 3 / WMO No. 49-2 Section 2.2. Also known as "CAVOK" When CAVOK conditions are observed, no other information on visibility, runway visual range, present weather, cloud amount, or cloud type is reported
prevailingVisibility	[0..1]	Distance	The prevailing horizontal visibility reported in a trend forecast
prevailingVisibilityOperator	[0..1]	RelationalOperator	The reported relational operator for the prevailing horizontal visibility. When reported, this operator is reported in conjunction with prevailing visibility. To report a prevailing visibility of at least 10000 meters, prevailing visibility is reported as 10000 meters and the operator is reported as "above". When no operator is reported, prevailing visibility represents an exact value with identical semantics to other measured quantities

D.2.8 AerodromeSurfaceWind

Type: Class.

Notes: An aggregation of surface wind conditions typically reported together at an aerodrome, including wind direction information, wind speed, and wind gusts.

Wind direction is reported according to ICAO Annex 3 / WMO No. 49-2 Section 4.1.5.2b.

Attribute	***Multi-plicity***	***Type***	***Notes***
extremeClockwiseWindDirection	[0..1]	Angle	The extreme clockwise direction from which the wind is blowing, inclusive. ICAO Annex 3 / WMO No. 49-2: Section 4.1.5.2b
extremeCounterClockwiseWindDirection	[0..1]	Angle	The extreme counter-clockwise direction from which the wind is blowing, inclusive. ICAO Annex 3 / WMO No. 49-2: Section 4.1.5.2b
meanWindDirection	[0..1]	Angle	The observed average wind direction from which the wind is blowing over the past ten minutes. Not reported when winds are variable
meanWindSpeed	[1]	Velocity	The average observed wind speed over the past ten minutes ICAO Annex 3 / WMO No. 49-2: Section 4.1.5.2a
variableDirection	[0..1]	Boolean	When true, indicates that the wind direction is variable. A wind direction value may still be reported
windGust	[0..1]	Velocity	The maximum wind speed observed over the past ten minutes ICAO Annex 3 / WMO No. 49-2: Section 4.1.5.2c

D.2.9 AerodromeHorizontalVisibility

Type: Class.

Notes: An aggregation of horizontal visibility conditions typically reported together at an aerodrome, including the prevailing visibility and minimum visibility.

Attribute	***Multi-plicity***	***Type***	***Notes***
minimumVisibility	[0..1]	Distance	The minimum observed visibility. ICAO Annex 3 / WMO No. 49-2 Section 4.2.4.4a: "When the visibility is not the same in different directions and a) when the lowest visibility is different from the prevailing visibility, and 1) less than 1500 m or 2) less than 50 percent of the prevailing visibility and less than 5000 m; the lowest visibility observed should also be reported and, when possible, its general direction in relation to the aerodrome reference point indicated by reference to one of the eight points of the compass. If the lowest visibility is observed in more than one direction, then the most operationally significant direction should be reported; and b) when the visibility is fluctuating rapidly, and the prevailing visibility cannot be determined, only the lowest visibility should be reported, with no indication of direction."
minimumVisibilityDirection	[0..1]	Angle	The direction of the minimum visibility relative to the reporting station. This is optional in cases where minimum visibility is reported but the visibility is fluctuating rapidly. Minimum visibility is reported in cardinal and inter-cardinal directions (N, NE, E, SE, S, SW, W, and NW)

Attribute	***Multi-plicity***	***Type***	***Notes***
prevailingVisibility	[1]	Distance	The reported prevailing horizontal visibility at the surface that is representative of the aerodrome. The greatest visibility value, observed in accordance with the definition of "visibility", which is reached within at least half the horizon circle or within at least half of the surface of the aerodrome. These areas could comprise contiguous or non-contiguous sectors. ICAO Annex 3 / WMO No. 49-2: Section 4.2.4.4b
prevailingVisibilityOperator	[0..1]	RelationalOperator	The reported relational operator for the prevailing horizontal visibility. When reported, this operator is reported in conjunction with prevailing visibility. To report a prevailing visibility of at least 10000 meters, prevailing visibility is reported as 10000 meters and the operator is reported as "above". When no operator is reported, prevailing visibility represents an exact value with identical semantics to other measured quantities

D.2.10 AerodromeSeaState

Type: Class.

Notes: An aggregation of sea state conditions typically reported together at an aerodrome. This includes information on sea-surface temperature and either the state of the sea or significant wave height from aeronautical meteorological stations established on offshore structures in support of helicopter operations

Attribute	*Multi-plicity*	*Type*	*Notes*
seaState	[0..1]	SeaSurfaceState	The state of the sea observed by aeronautical meteorological stations established on offshore structures in support of helicopter operations ICAO Annex 3 / WMO No. 49-2: Section 4.8.1.5a WMO 306: Table 3700
seaSurfaceTemperature	[1]	Measure	The sea-surface temperature observed by aeronautical meteorological stations established on offshore structures in support of helicopter operations. The term sea surface temperature is generally meant to be representative of the upper few meters of the ocean as opposed to the skin temperature, which is the temperature of the upper few centimeters. ICAO Annex 3 / WMO No. 49-2: Section 4.8.1.5a
significantWaveHeight	[0..1]	Distance	The significant wave height observed

D.2.11 SeaSurfaceState

Type: Class.

Notes: Categorical assessment of sea surface state (or other large open body of water) based on height of waves.

See WMO No. 306 Vol I.1 code table 3700 "State of the sea" and WMO No. 306 Vol I.2 FM 94 BUFR code table 0 22 061 "State of the sea".

D.2.12 AerodromeRunwayVisualRange

Type: Class.

Notes: An aggregation of runway visual range conditions for a single runway, typically reported together at an aerodrome

Attribute	***Multi-plicity***	***Type***	***Notes***
meanRVR	[1]	Distance	The mean recent runway visual range value observed. This mean represents the 10 minute average for observed RVR except when the 10-minute period immediately preceding the observation includes a marked discontinuity in runway visual range values, only those values occurring after the discontinuity is used for obtaining mean values. To report a mean RVR of at least 2000 meters, mean RVR is reported as 2000 meters and the operator is reported as "above" Annex 3: Table A3-2 "RVR/RVR" Section 4.3.6.6
meanRVROperator	[0..1]	RelationalOperator	The reported relational operator for the mean RVR. When reported, this operator is reported in conjunction with mean RVR. To report a mean RVR of at least 2000 meters, mean RVR is reported as 2000 meters and the operator is reported as "above". When no operator is reported, mean RVR represents an exact value with identical semantics to other measured quantities
pastTendency	[0..1]	VisualRangeTendency	The runway visual range tendency (up, down, none). If the runway visual range values during the 10-minute period have shown a distinct tendency, such that the mean during the first 5 minutes varies by 100 m or more from the mean during the second 5 minutes of the period, this should be indicated. When the variation of the runway visual range values shows an upward or downward tendency, this should be indicated by "Up" or "Down", respectively. In circumstances when actual fluctuations during the 10-minute period show no distinct tendency, this should be indicated using "No Change?. When indications of tendency are not available, no information should be reported ICAO Annex 3 / WMO No. 49: Table A3-2 Note 9 Section 4.3.6.6a
runway	[1]	RunwayDirection	The runway to which reported runway visual range information applies

D.2.13 VisualRangeTendency

Type: Enumeration.

Notes: The tendency of visual range (e.g., upward, downward). Defined for the purposes of aviation meteorology reporting of the visual range on runways (WMO No. 49-2).

If the [runway] visual range (RVR) values during the 10-minute period preceding the nominal observation time show a distinct upward or downward tendency such that the mean during the first five minutes varies by 100 metres or more from the mean in the second five minutes of the period, an UPWARD [U] or DOWNWARD [D] tendency is recorded. When no distinct change in RVR is observed, NO CHANGE [N] is recorded.

See WMO No. 306 Vol I.2 FM 94 BUFR code-table 0 20 018 "Tendency of runway visual range".

Attribute	***Multi-plicity***	***Type***	***Notes***
UPWARD	[1]		Upward (increasing) tendency
NO_CHANGE	[1]		No change
DOWNWARD	[1]		Downward (decreasing) tendency

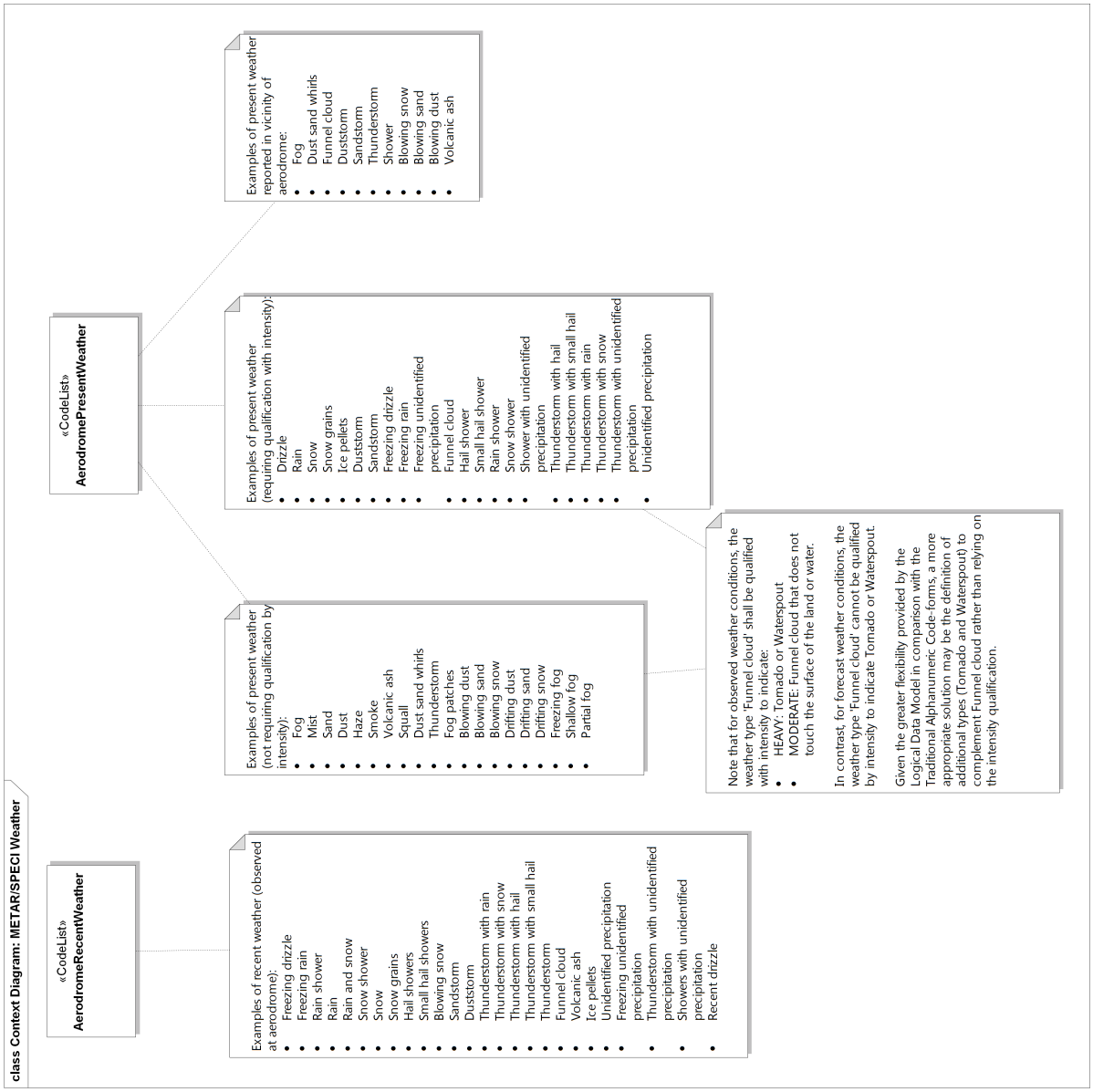
D.2.14 AerodromePresentWeather

Type: Class.

Notes: The present weather observed at, or in near vicinity of, an aerodrome.

Only a specific set of weather phenomenon are reported within aviation meteorology as defined in Regulation ICAO Annex 3 / WMO No. 49-2.

This CodeList is specifically defined for aviation purposes as defined in WMO No. 49-2. A superset of definitions are defined in WMO No. 306 Vol I.1 code-table 4678 "Significant weather phenomena".


class Context Diagram: METAR/SPECI Weather
«CodeList»
AerodromeRecentWeather
Examples of recent weather (observed at aerodrome):
Freezing drizzle
Freezing rain
Rain shower
Rain
Rain and snow
Snow shower
Snow
Snow grains
Hail showers
Small hail showers
Blowing snow
Sandstorm
Duststorm
Thunderstorm with rain
Thunderstorm with snow
Thunderstorm with hail
Thunderstorm with small hail
Thunderstorm
Funnel cloud
Volcanic ash
Ice pellets
Unidentified precipitation
Freezing unidentified precipitation
Thunderstorm with unidentified precipitation
Showers with unidentified precipitation
Recent drizzle
«CodeList»
AerodromePresentWeather
Examples of present weather (not requiring qualification by intensity):
Fog
Mist
Sand
Dust
Haze
Smoke
Volcanic ash
Squall
Dust sand whirls
Thunderstorm
Fog patches
Blowing dust
Blowing sand
Blowing snow
Drifting dust
Drifting sand
Drifting snow
Freezing fog
Shallow fog
Partial fog
Examples of present weather (requiring qualification with intensity):
Drizzle
Rain
Snow
Snow grains
Ice pellets
Duststorm
Sandstorm
Freezing drizzle
Freezing rain
Freezing unidentified precipitation
Funnel cloud
Hail shower
Small hail shower
Rain shower
Snow shower
Shower with unidentified precipitation
Thunderstorm with hail
Thunderstorm with small hail
Thunderstorm with rain
Thunderstorm with snow
Thunderstorm with unidentified precipitation
Unidentified precipitation
Examples of present weather reported in vicinity of aerodrome:
Fog
Dust sand whirls
Funnel cloud
Duststorm
Sandstorm
Thunderstorm
Shower
Blowing snow
Blowing sand
Blowing dust
Volcanic ash
Note that for observed weather conditions, the weather type 'Funnel cloud' shall be qualified with intensity to indicate:
HEAVY: Tornado or Waterspout
MODERATE: Funnel cloud that does not touch the surface of the land or water.
In contrast, for forecast weather conditions, the weather type 'Funnel cloud' cannot be qualified by intensity to indicate Tornado or Waterspout.
Given the greater flexibility provided by the Logical Data Model in comparison with the Traditional Alphanumeric Code-forms, a more appropriate solution may be the definition of additional types (Tornado and Waterspout) to complement Funnel cloud rather than relying on the intensity qualification.

D.2.15 AerodromeObservedClouds

Type: Class.

Notes: An aggregation of observed cloud conditions typically reported together at an aerodrome, including cloud types, cloud layers, and vertical visibility.

Attribute	***Multi-plicity***	***Type***	***Notes***
amountAndHeightUnobservableByAutoSystem	[0..1]	Boolean	An automatic observing system observed cumulonimbus clouds or towering cumulus clouds but the cloud amount and height could not be observed ICAO Annex 3 / WMO No. 49-2: Section 4.5.4.5c – When cumulonimbus clouds or towering cumulus clouds are detected by the automatic observing system and the cloud amount and the height of cloud base cannot be observed, the cloud amount and the height of cloud base should be replaced by "//////"
verticalVisibility	[0..1]	LengthWithNilReason	The reported vertical visibility. Vertical visibility is defined as the vertical visual range into an obscuring medium. Note: vertical visibility is only reported in aviation-specific WMO Code-forms (FM-15 METAR, FM-16 SPECI and FM-51 TAF) thus prevailing visibility is considered to be an aviation-specific quantity. When the sky is obscured and the value of the vertical visibility cannot be determined by the automatic observing system due to a temporary failure of the system/sensor ("VV///") the vertical visibility is missing with a nil reason of notObservable

D.2.16 AerodromeRecentWeather

Type: Class.

Notes: Weather phenomenon of operational significance to aviation observed during the period since the last routine report, or last hour, whichever is shorter, but not at the time of observation.

Only a specific set of weather phenomenon are reported within aviation meteorology as defined in Regulation ICAO Annex 3 / WMO No. 49-2.

This CodeList is specifically defined for aviation purposes as defined in WMO No. 49-2. A superset of definitions are defined in WMO No. 306 Vol I.1 code-table 4678 "Significant weather phenomena".

D.2.17 AerodromeWindShear

Type: Class.

Notes: An aggregation of wind shear conditions typically reported together at an aerodrome, including the set of affected runways.

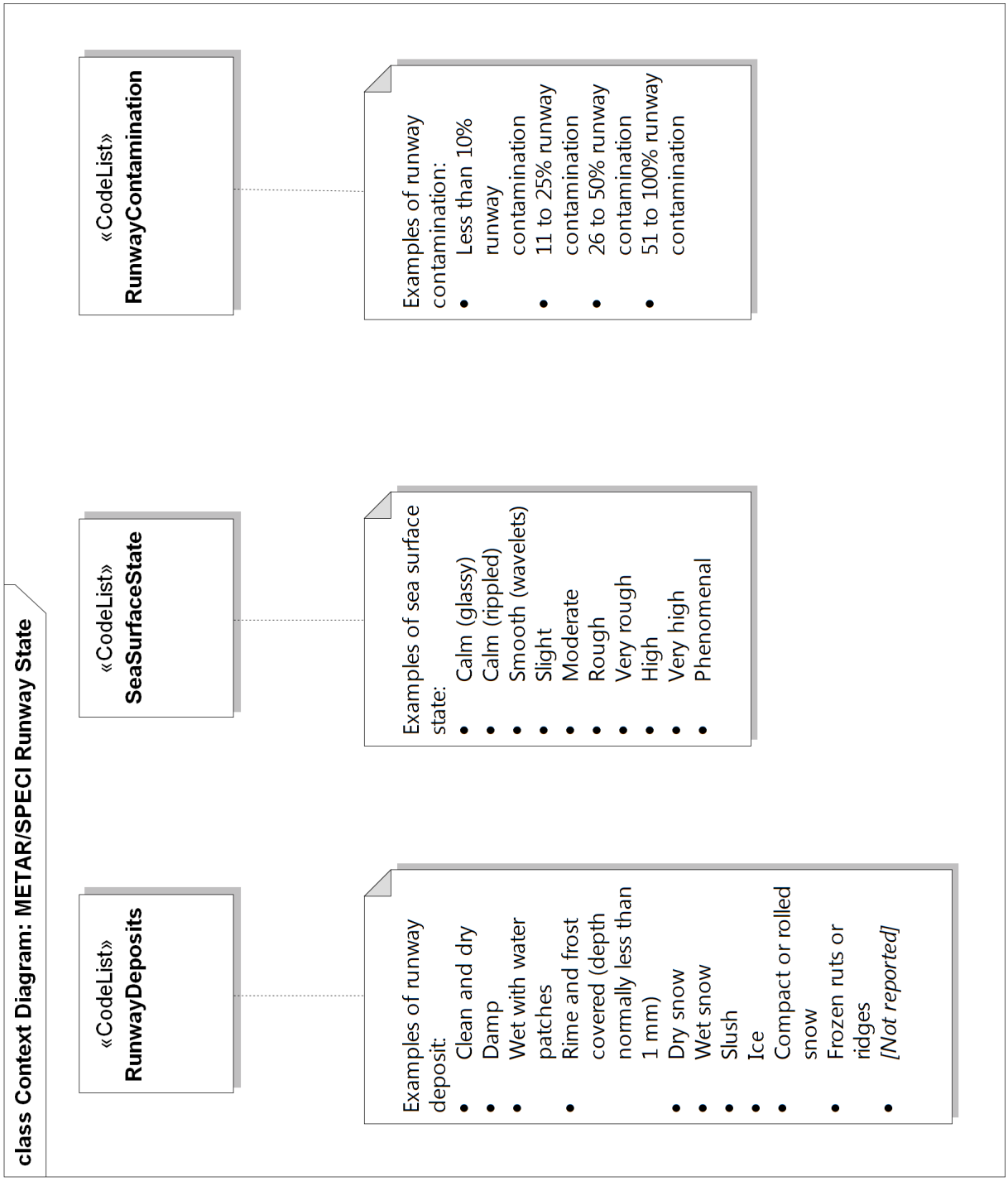
Attribute	***Multi-plicity***	***Type***	***Notes***
allRunways	[0..1]	Boolean	When true, all runways are observed to have wind shear
runway	[0..*]	RunwayDirection	The specific runway(s) affected by wind shear at this aerodrome. No specific runways are reported when all runways are affected by wind shear

D.2.18 AerodromeRunwayState

Type: Class.

Notes: An aggregation of runway conditions typically reported together at an aerodrome, including the runway contamination, friction, and deposits.

Attribute	***Multi-plicity***	***Type***	***Notes***
allRunways	[0..1]	Boolean	When true, indicates the reported conditions apply to all runways
cleared	[0..1]	Boolean	Indicates that reported runway has been cleared of meteorological deposits, such as snow. ICAO Annex 3 / WMO No. 49-2: "CLRD" Section 4.8.1.5, Table A3-2 "State of the runway"
contamination	[0..1]	RunwayContamination	Proportion of runway surface that is contaminated – usually expressed as a percentage of the total runway area. See WMO No. 306: WMO Code table 0519 and BUFR Code table 0 20 087
depositType	[0..1]	RunwayDeposits	The type of runway deposit, such as damp conditions, wet snow, or ice. WMO 306: Table 0919
depthOfDeposit	[0..1]	Distance	Depth of deposit on the surface of the runway. See WMO No. 306 WMO Code table 1079.
estimatedSurface Friction	[0..1]	Scale	The estimated surface friction for the affected runway. Between 0.0 and 0.9. When braking conditions are not reported and/or the runway is not operational estimatedSurfaceFriction will not be reported. WMO 306: Table 0366
estimatedSurface FrictionUnreliable	[0..1]	Boolean	When true, the estimated surface friction is unreliable and is not reported. WMO 306: Table 0366
runway	[0..1]	RunwayDirection	The runway to which the conditions apply. The runway may be missing in cases where all runways are closed due to snow
snowClosure	[0..1]	Boolean	Indicates whether the aerodrome is closed due to an extreme deposit of snow. This affects all runways WMO 306: Section 15.13.6.1


class Context Diagram: METAR/SPECI Runway State
«CodeList»
RunwayDeposits
Examples of runway deposit:
• Clean and dry
• Damp
• Wet with water patches
• Rime and frost covered (depth normally less than 1 mm)
• Dry snow
• Wet snow
• Slush
• Ice
• Compact or rolled snow
• Frozen ruts or ridges
• [Not reported]
«CodeList»
SeaSurfaceState
Examples of sea surface state:
• Calm (glassy)
• Calm (rippled)
• Smooth (wavelets)
• Slight
• Moderate
• Rough
• Very rough
• High
• Very high
• Phenomenal
«CodeList»
RunwayContamination
Examples of runway contamination:
• Less than 10% runway contamination
• 11 to 25% runway contamination
• 26 to 50% runway contamination
• 51 to 100% runway contamination

D.2.19 RunwayContamination

Type: Class.

Notes: Extent of runway surface that is contaminated (covered)

D.2.20 RunwayDeposits

Type: Class.

Notes: Type of deposit on a runway.

See WMO No. 306 Vol I.1 code table 0919 and WMO No. 306 Vol I.2 FM 94 BUFR code table 0 20 086 "Runway deposits".

D.2.21 MeteorologicalAerodromeReportStatus

Type: Enumeration.

Notes: The status of a MeteorologicalAerodromeObservationReport (e.g., a normal issuance, correction of an earlier report, etc.)

Attribute	***Multi-plicity***	***Type***	***Notes***
NORMAL	[1]		Normal report status: not a correction of an earlier report
CORRECTION	[1]		A correction of an earlier report
MISSING	[1]		The report is missing ("NIL" from ICAO Annex 3 / WMO No. 49)

D.2.22 ForecastChangeIndicator

Type: Enumeration.

Notes: Change qualifier of a trend-type forecast or an aerodrome forecast.

Defined in WMO No. 306 Vol I.1; FM-15 METAR, FM-16 SPECI and FM-51 TAF.

Also see WMO No. 306 Vol I.2 Part B FM 94 BUFR code-table 0 08 016 'Change qualifier of a trend forecast or an aerodrome forecast'.

Attribute	***Multi-plicity***	***Type***	***Notes***
NO_SIGNIFICANT_CHANGES	[1]		No significant changes are forecast (NOSIG)
BECOMING	[1]		When the change is forecast to commence at the beginning of the forecast period and be completed by the end of that period, or when the change is forecast to occur within the forecast period but the time of the change is uncertain (possibly shortly after the beginning of the forecast period, or midway or near the end of that period), the change is indicated by only the change indicator BECMG.
TEMPORARY_FLUCTUATIONS	[1]		The change indicator TEMPO is used to describe expected temporary fluctuations to meteorological conditions which reach or pass specified threshold criteria and last for a period of less than one hour in each instance and in the aggregate cover less than half of the forecast period during which the fluctuations are expected to occur.

ANNEX E: ABRIDGED CLASS DEFINITIONS AND CONTEXT DIAGRAMS FOR THE ICAO METEOROLOGICAL INFORMATION EXCHANGE MODEL (IWXXM), TAF

E.1 Introduction

The authoritative version of the METCE is maintained within AvXML as an online resource at the following URL: http://wis.wmo.int/AvXML/AvXML-1.1/index.htm. What follows is abridged to suit the needs of the print medium.

E.2 The TAF leaf of IWXXM

The TAF leaf of the ICAO Meteorological Information Exchange Model (IWXXM) models the TAF reporting constructs as defined in ICAO Annex 3 / WMO No. 49-2.

An Aerodrome Forecast (TAF) report is a routine forecast of meteorological conditions at an aerodrome intended for distribution. TAF reports include base forecast conditions, and modifications to those conditions throughout the valid period.

E.2.1 TAF

Type: Class.

Notes: An Aerodrome Forecast (TAF) report is a routine aerodrome forecast intended for distribution beyond an aerodrome. TAF reports report base forecast conditions, and modifications to those conditions throughout the valid period.

TAF reports include similar information to a METAR/SPECI trend forecast. However, TAF forecast information includes additional detail.

Aerodromes can issue both METAR/SPECI and TAF reports on a routine basis, but TAFs are not issued by every METAR-reporting aerodrome.

The issuance of a new forecast by a meteorological office, such as a TAF, cancels any forecast of the same type previously issued for the same place and for the same period of validity or part thereof.

Prevailing conditions and forecast changes differ in that the prevailing conditions can include temperatures, base conditions do not include a change indicator, and that forecast changes may report no significant weather (NSW). Rather than have two class hierarchies, constraints are present ensuring that each (base and forecast conditions) only include relevant information

Attribute	*Multi-plicity*	*Type*	*Notes*
baseForecast	[0..1]	MeteorologicalAerodromeForecast	The prevailing conditions. Mandatory in all cases except missing or cancelled reports
changeForecast	[0..*]	MeteorologicalAerodromeForecast	Forecast that modifies the base forecast. While there is no maximum number of forecasts, this should normally not exceed five in number. ICAO Annex 3 / WMO No. 49-2: Section 1.5: "The number of change and probability groups should be kept to a minimum and should not normally exceed five groups".
issueTime	[1]	TM_Instant	The time at which this report was issued. Note that this should be identical to the resultTime of each MeteorologicalAerodromeForecast, whose results are made available at the same time as this report. TAF reports have an issueTime to assist in discovery and to provide unambiguous semantics at the report level.
previousReportAerodrome	[0..1]	Aerodrome	The aerodrome of the previously-issued report being amended or cancelled
previousReportValidPeriod	[0..1]	TM_Period	The valid time period for the previously amended and/or cancelled report
status	[1]	TAFReportStatus	The status of this report, including amended, cancelled, normal, or corrected. Missing reports indicate that a report was not issued from the responsible reporting party as expected. Missing reports are typically issued by third parties that were expecting a report.
validTime	[0..1]	TM_Period	The time frame at which this report is valid. All forecast elements should be valid within this period

class Context Diagram: TAF

«FeatureType»
TAF

+ baseForecast :MeteorologicalAerodromeForecast [0..1]
+ changeForecast :MeteorologicalAerodromeForecast [0..*]
+ issueTime :TM_Instant
+ previousReportAerodrome :Aerodrome [0..1]
+ previousReportValidPeriod :TM_Period [0..1]
+ status :TAFReportStatus
+ validTime :TM_Period [0..1]

constraints

{forAll(self.forecastConditions.temperature == null)}
{if(status == NORMAL) previousReportValidPeriod == null}
{if(status == AMENDED) previousReportValidPeriod != null}
{if(status == CANCELLED) previousReportValidPeriod != null}
{if(status == CORRECTION) previousReportValidPeriod != null}
{self.changeForecasts.forAll(self.baseForecast.resultTime == self.resultTime)}
{self.issueTime == baseForecast.resultTIme}
{self.baseForecast.changeIndicator == null}
{if(status == MISSING) baseForecast.result includes nilReason AND validTime == NULL AND pr...
{let exclTerm : Set(String) = Set{'FROM', 'BECOMING'} in self.changeForecast->asSequence(...
{if(status != MISSING) validTime != NULL}

«Enumeration»
TAFReportStatus

NORMAL
AMENDMENT
CANCELLATION
CORRECTION
MISSING

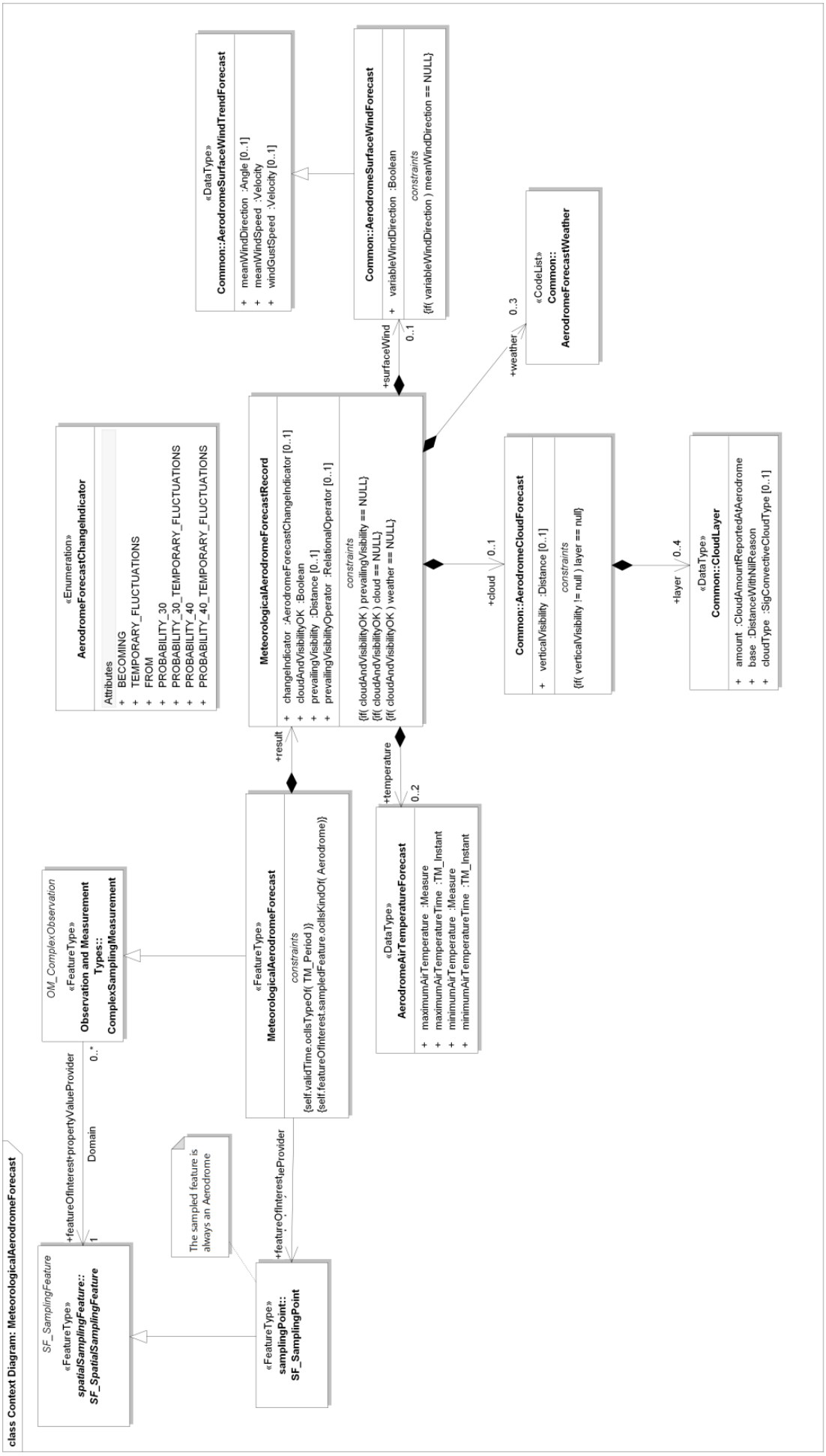
E.2.2 MeteorologicalAerodromeForecast

Type: Class.

Notes: A specialized OM_Observation type used for reporting an aggregate set of forecast meteorological conditions at an Aerodrome. The result of this observation type refers to an entity of type MeteorologicalAerodromeForecastRecord.

MeteorologicalAerodromeForecast enforces one constraint--the sampled feature must be an Aerodrome. This class is also related but not identical to MeteorologicalAerodromeTrendForecast which is reported on a METAR/SPECI – conditions reported in trend forecasts in METAR/SPECI differ from forecast groups in a TAF.

The TAF forecast group from/to variants (FM, TL, AT, etc.) are represented on the OM_Observation validTime, which is always an instance of TM_Period. When there is only an instant at which a condition occurs, the start and end time are the same.


class Context Diagram: MeteorologicalAerodromeForecast
«DataType»
Common::AerodromeSurfaceWindTrendForecast
+ meanWindDirection :Angle [0..1]
+ meanWindSpeed :Velocity
+ windGustSpeed :Velocity [0..1]
Common::AerodromeSurfaceWindForecast
+ variableWindDirection :Boolean
constraints
{if(variableWindDirection) meanWindDirection == NULL}
+surfaceWind
0..1
+weather
0..3
«CodeList»
Common::
AerodromeForecastWeather
«Enumeration»
AerodromeForecastChangeIndicator
Attributes
+ BECOMING
+ TEMPORARY_FLUCTUATIONS
+ FROM
+ PROBABILITY_30
+ PROBABILITY_30_TEMPORARY_FLUCTUATIONS
+ PROBABILITY_40
+ PROBABILITY_40_TEMPORARY_FLUCTUATIONS
MeteorologicalAerodromeForecastRecord
+ changeIndicator :AerodromeForecastChangeIndicator [0..1]
+ cloudAndVisibilityOK :Boolean
+ prevailingVisibility :Distance [0..1]
+ prevailingVisibilityOperator :RelationalOperator [0..1]
constraints
{if(cloudAndVisibilityOK) prevailingVisibility == NULL}
{if(cloudAndVisibilityOK) cloud == NULL}
{if(cloudAndVisibilityOK) weather == NULL}
+cloud
0..1
Common::AerodromeCloudForecast
+ verticalVisibility :Distance [0..1]
constraints
{if(verticalVisibility != null) layer == null}
+layer
0..4
«DataType»
Common::CloudLayer
+ amount :CloudAmountReportedAtAerodrome
+ base :DistanceWithNilReason
+ cloudType :SigConvectiveCloudType [0..1]
+result
+temperature
0..2
«DataType»
AerodromeAirTemperatureForecast
+ maximumAirTemperature :Measure
+ maximumAirTemperatureTime :TM_Instant
+ minimumAirTemperature :Measure
+ minimumAirTemperatureTime :TM_Instant
«FeatureType»
MeteorologicalAerodromeForecast
constraints
{self.validTime.oclIsTypeOf(TM_Period)}
{self.featureOfInterest.sampledFeature.oclIsKindOf(Aerodrome)}
OM_ComplexObservation
«FeatureType»
Observation and Measurement
Types::
ComplexSamplingMeasurement
+featureOfInterest:propertyValueProvider
1
Domain
0..*
The sampled feature is
always an Aerodrome
+featureOfInterest:eProvider
SF_SamplingFeature
«FeatureType»
spatialSamplingFeature::
SF_SpatialSamplingFeature
«FeatureType»
samplingPoint::
SF_SamplingPoint

E.2.3 MeteorologicalAerodromeForecastRecord

Type: Class.

Notes: A specialized Record type containing meteorological conditions forecast at an aerodrome. This class is also related but not identical to MeteorologicalAerodromeTrendForecastRecord, which is reported on a METAR/SPECI – conditions reported in trend forecasts in METAR/SPECI differ from forecast groups in a TAF.

When no clouds of operational significance or no weather of operational significance is predicted, the nothingOfOperationalSignificance nilReason should be used for the cloud or presentWeather association.

Note that the TAC representations for "FM", "TL", and "AT" are represented by the phenomenonTime on the change forecast (MeteorologicalAerodromeForecast):

FM and TL – a phenomenonTime with a TimePeriod (start is FM and end is TL)

TL – a phenomenonTime with a TimePeriod (start is beginning of forecast validity and end is TL)

FM – a phenomenonTime with a TimePeriod (start is FM and end is end of forecast validity)

AT – a phenomenonTime with a TimeInstant

Attribute	***Multi-plicity***	***Type***	***Notes***
changeIndicator	[0..1]	AerodromeForecastChangeIndicator	The type of change being reported (FROM, BECOMING, TEMPORARY, etc.). A change indicator is required for all MeteorologicalAerodromeForecastRecords excepting reported base conditions.

Attribute	*Multi-plicity*	*Type*	*Notes*
cloudAndVisibilityOK	[1]	Boolean	When true, indicates that the observed cloud ceiling, horizontal visibility, and weather conditions are of no operational significance. See ICAO Annex 3 / WMO No. 49-2 Section 2.2. Also known as "CAVOK" When CAVOK conditions are observed, no other information on visibility, runway visual range, present weather, cloud amount, or cloud type is reported
prevailingVisibility	[0..1]	Distance	The prevailing horizontal visibility, mandatory except when ceiling and visibility is reported as OK
prevailingVisibilityOperator	[0..1]	RelationalOperator	The reported relational operator for the prevailing horizontal visibility. When reported, this operator is reported in conjunction with prevailing visibility. To report a prevailing visibility of at least 10000 meters, prevailing visibility is reported as 10000 meters and the operator is reported as "above". When no operator is reported, prevailing visibility represents an exact value with identical semantics to other measured quantities

E.2.4 TAFReportStatus

Type: Enumeration.

Notes: The report status for a TAF report (e.g., a normal issuance, an amendment of an earlier report, a cancellation of an earlier report)

Attribute	*Multi-plicity*	*Type*	*Notes*
NORMAL	[1]		An normal issuance of a TAF
AMENDMENT	[1]		An amendment of an earlier TAF
CANCELLATION	[1]		A cancellation of an earlier TAF
CORRECTION	[1]		A correction of an earlier TAF
MISSING	[1]		The report is missing ("NIL" from ICAO Annex 3 / WMO No. 49)

E.2.5 AerodromeForecastChangeIndicator

Type: Enumeration.

Notes: The forecast change indicator type, including temporary, permanent, or probable conditions. This is an extension of ForecastChangeIndicator that includes report-specific entries, and in particular the 30 and 40% probability conditions.

Note that the TAC representations for "FM", "TL", and "AT" are represented by the phenomenonTime on the change forecast (MeteorologicalAerodromeForecast):

FM and TL – a phenomenonTime with a TimePeriod (start is FM and end is TL)

TL – a phenomenonTime with a TimePeriod (start is beginning of forecast validity and end is TL)

FM – a phenomenonTime with a TimePeriod (start is FM and end is end of forecast validity)

AT – a phenomenonTime with a TimeInstant

Design note:

These values represent the operationally-representable types, but are not very general-purpose. Especially with temporary conditions and probability it might be better to turn these into a "probability" property and constraints could be applied to the value to match operational constraints

Attribute	***Multi-plicity***	***Type***	***Notes***
BECOMING	[1]		Conditions are expected to reach or pass through specified threshold values at a regular or irregular rate and at an unspecified time during the time period. The time period should normally not exceed 2 hours but in any case should not exceed 4 hours. ICAO Annex 3 / WMO No. 49-2: "BECMG"
TEMPORARY_FLUCTUATIONS	[1]		Expected temporary fluctuations to meteorological conditions which reach or pass specified threshold criteria and last for a period of less than one hour in each instance and in the aggregate cover less than half of the forecast period during which the fluctuations are expected to occur. ICAO Annex 3 / WMO No. 49-2: "TEMPO"
FROM	[1]		One set of prevailing weather conditions is expected to change significantly and more or less completely to a different set of conditions. Conditions in a FROM group supersede conditions in earlier groups. ICAO Annex 3 / WMO No. 49-2: "FM"

PROBABILITY_30	[1]		A 30% probability of occurrence of an alternative value of a forecast element or elements. ICAO Annex 3 / WMO No. 49-2: "PROB30"
PROBABILITY_30_TEMPORARY_FLUCTUATIONS	[1]		A 30% probability of occurrence of temporary conditions of an alternative value of a forecast element or elements. ICAO Annex 3 / WMO No. 49-2: "PROB30 TEMPO"
PROBABILITY_40	[1]		A 40% probability of occurrence of an alternative value of a forecast element or elements. ICAO Annex 3 / WMO No. 49-2: "PROB40"
PROBABILITY_40_TEMPORARY_FLUCTUATIONS	[1]		A 40% probability of occurrence of temporary conditions of an alternative value of a forecast element or elements. ICAO Annex 3 / WMO No. 49-2: "PROB40 TEMPO"

E.2.6 AerodromeAirTemperatureForecast

Type: Class.

Notes: An aggregation of air temperature forecast conditions typically reported together at an aerodrome, including the minimum and maximum anticipated air temperatures and when they occur.

AerodromeAirTemperatureForecast is only reported on base conditions on a TAF, not change forecasts.

Attribute	*Multi-plicity*	*Type*	*Notes*
maximumAirTemperature	[1]	Measure	The maximum air temperature ICAO Annex 3 / WMO No. 49-2: "TX"
maximumAirTemperatureTime	[1]	TM_Instant	The time of occurrence of the maximum air temperature. This must be within the period of the phenomenon time for this forecast record ICAO Annex 3 / WMO No. 49-2: "TX"
minimumAirTemperature	[1]	Measure	The minimum air temperature ICAO Annex 3 / WMO No. 49-2: "TN"
minimumAirTemperatureTime	[1]	TM_Instant	The time of occurrence of the minimum air temperature. This must be within the period of the phenomenon time for this forecast record ICAO Annex 3 / WMO No. 49-2: "TN"

ANNEX F: ABRIDGED CLASS DEFINITIONS AND CONTEXT DIAGRAMS FOR THE ICAO METEOROLOGICAL INFORMATION EXCHANGE MODEL (IWXXM), SIGMET

F.1 Introduction

The authoritative version of IWXXM is maintained within AvXML as an online resource at the following URL: http://wis.wmo.int/AvXML/AvXML-1.0/index.htm. What follows is abridged to suit the needs of the print medium.

F.2 The SIGMET leaf of IWXXM

Notes: The SIGMET leaf of the ICAO Meteorological Information Exchange Model (IWXXM) models the SIGMET reporting constructs as defined in ICAO Annex 3 / WMO No. 49-2.

SIGMETs report the occurrence and/or expected occurrence of specified en-route weather phenomena which may affect the safety of aircraft operations, and of the development of those phenomena in time and space. These weather phenomena are reported as impacted regions of airspace.

F.2.1 SIGMET

Type: Class.

Notes: A SIGMET (significant meteorological) report. SIGMETs report the occurrence and/or expected occurrence of specified en-route weather phenomena which may affect the safety of aircraft operations, and of the development of those phenomena over time.

The SIGMET report class represents the base SIGMET types that may be reported such as squall lines, thunderstorms, dust storms, turbulence, etc. Tropical cyclone and volcanic ash SIGMET reports are subclasses of SIGMET due to their ability to report additional information, including volcano/tropical cyclone identification and forecast position(s).

SIGMETs may report either observed or forecast hazardous conditions. Additionally, a forecast position may be reported.

Attribute	***Multi-plicity***	***Type***	***Notes***
analysis	[0..*]	SIGMETEvolvingConditionAnalysis	SIGMETs may include the same phenomenon covering more than one area within the FIR/UIR/CTA, as well as observed and forecast conditions for each of these reported areas. All combinations of observations and forecasts of meteorological conditions, including changing conditions, are represented by their own SIGMETEvolvingMeteorologicalCondition. Each analysis has a single EvolvingMeteorologicalCondition as its result.
cancelledSequenceNumber	[0..1]	CharacterString	The cancelled SIGMET sequence number. Mandatory when this is a cancellation report, must be missing otherwise Examples: YUDD SIGMET 2 VALID ... YUDD SIGMET A3 VALID ...
cancelledValidPeriod	[0..1]	TM_Period	The valid period of a previous SIGMET that is cancelled by this SIGMET. Mandatory when this is a cancellation report, must be missing otherwise
forecastPositionAnalysis	[0..1]	SIGMETPositionAnalysis	One or more forecast positions at the end of the valid period – one for each phenomenon area within an FIR. These are modelled as a single OM_Observation sub-type with a feature collection result due to the shared time and other observation metadata for all forecast positions.

Attribute	***Multi-plicity***	***Type***	***Notes***
issuingAirTrafficServicesUnit	[1]	Unit	The ATS unit serving the FIR or CTA to which the SIGMET refers ICAO Annex 3 / WMO No. 49-2: A6-1: "Location indicator of FIR/CTA"
OriginatingMeteorologicalWatchOffice	[1]	Unit	MWO originating this report
phenomenon	[1]	AeronauticalSignificantWeatherPhenomenon	The reported phenomenon, such as thunderstorm, tropical cyclone, icing, mountain wave, etc. The expected end of occurrence of volcanic ash ("NO VA EXP") is indicated with a missing SIGMET phenomenon with a nil reason of nothingOfOperationalSignificance
sequenceNumber	[1]	CharacterString	The sequence number of this message. For example: "5", "A3", or "2"
status	[1]	SIGMETReportStatus	The SIGMET report status – cancelled or normal
validPeriod	[1]	TM_Period	The valid period for the entire report, including all observations and forecast conditions. Each observation/forecast phenomenon includes its own period of validity for described meteorological conditions, which is represented as the O&M Observation validTime. For example, an issued tropical cyclone SIGMET may be valid from 1600 UTC to 2200 UTC with an observed position at 1600 UTC and a forecast position of the centre of the tropical cyclone at 2200 UTC. In this case the SIGMET validPeriod would be 1600 UTC to 2200 UTC, the analysis validTime would be 1600 UTC, and the forecastPositionAnalysis validTime would be 2200 UTC.

class Context Diagram: SIGMET
«FeatureType»
SIGMET
+ analysis :SIGMETEvolvingConditionAnalysis [0..*]
+ cancelledSequenceNumber :CharacterString [0..1]
+ cancelledValidPeriod :TM_Period [0..1]
+ forecastPositionAnalysis :SIGMETPositionAnalysis
+ issuingAirTrafficServicesUnit :Unit
+ originatingMeteorologicalWatchOffice :Unit
+ phenomenon :AeronauticalSignificantWeatherPhenomenon
+ sequenceNumber :CharacterString
+ status :SIGMETReportStatus
+ validPeriod :TM_Period
constraints
{self.classification.result.oclIsKindOf(EvolvingMeteorologicalCondition)}
{if(status == CANCELLATION) analysis.result includes nilReason}
{if(status == NORMAL) analysis.result excludes nilReason AND analysis.size() > 0}
{self.forecastPositionAnalysis.result.member.oclIsKindOf(MeteorologicalPosition)}
«Enumeration»
SIGMETReportStatus
NORMAL
CANCELLATION
«FeatureType»
VolcanicAshSIGMET
+ eruptingVolcano :Volcano
«FeatureType»
TropicalCycloneSIGMET
+ tropicalCyclone :TropicalCyclone
«CodeList»
AeronauticalSignificantWeatherPhenomenon
Examples of significant weather phenomena:
- Obscured thunderstorm (OBSC_TS)
- Obscured thunderstorm with hail (OBSC_TSGR)
- Embedded thunderstorm (EMBD_TS)
- Embedded thunderstorm with hail (EMBD_TSGR)
- Frequent thunderstorm (FRQ_TS)
- Frequent thunderstorm with hail (FRQ_TSGR)
- Squall line (SQL_TS)
- Squall line with hail (SQL_TSGR)
- Tropical cyclone (TC)
- Severe turbulence (SEV_TURB)
- Severe airframe icing (SEV_ICE)
- Severe airframe icing from freezing rain (SEV_ICE_FZRA)
- Severe mountain wave (SEV_MTW)
- Heavy dust storm (HVY_DS)
- Heavy sand storm (HVY_SS)
- Volcanic ash (VA)
- Radioactive cloud (RDOACT_CLD)

F.2.2 TropicalCycloneSIGMET

Type: Class.

Notes: A SIGMET that reports the presence of a tropical cyclone conditions. This extends the base SIGMET type by including additional information necessary for tropical cyclones.

Attribute	***Multi-plicity***	***Type***	***Notes***
tropicalCyclone	[1]	TropicalCyclone	The tropical cyclone being reported in this SIGMET

F.2.3 VolcanicAshSIGMET

Type: Class.

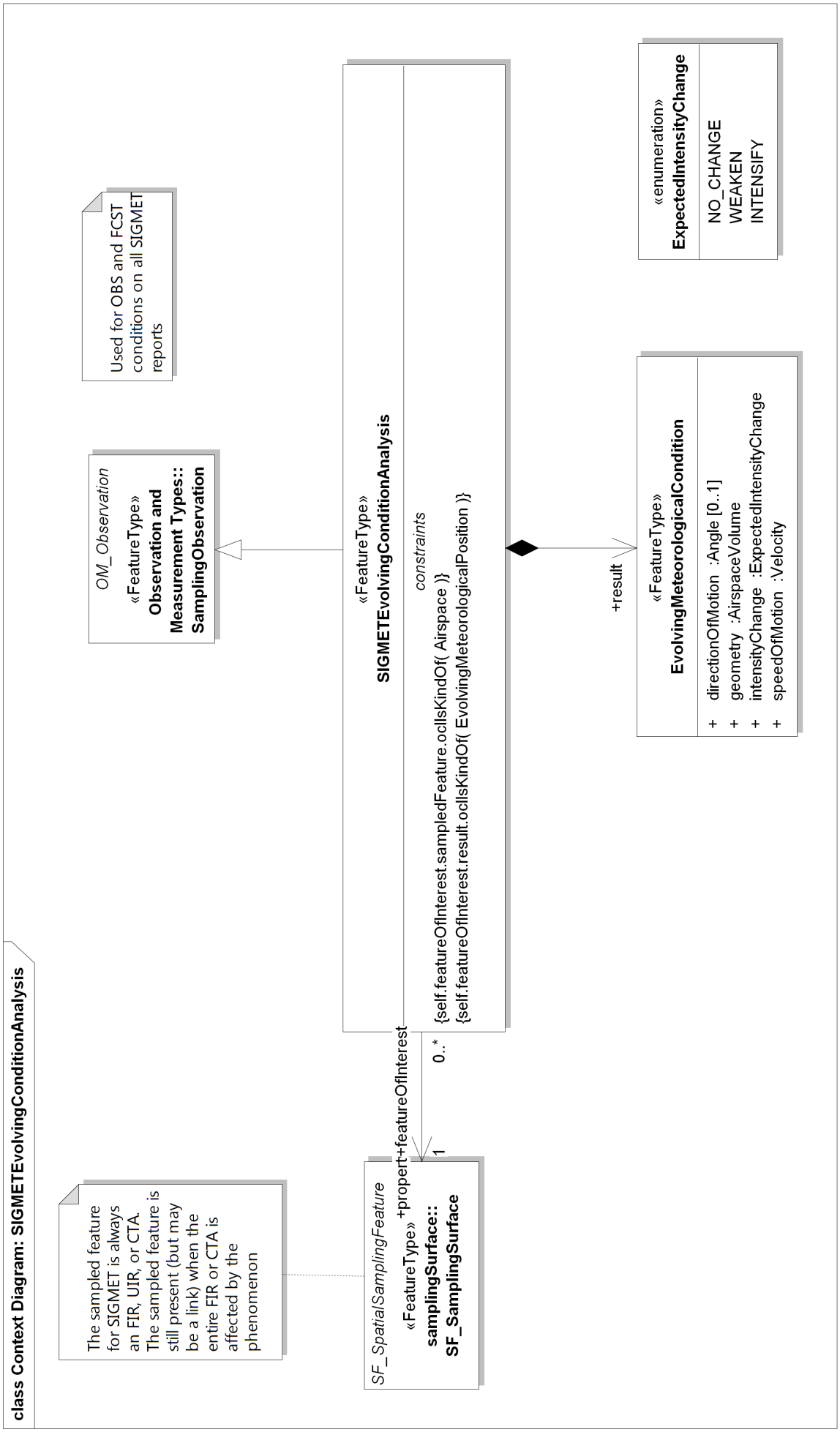
Notes: A SIGMET that reports the presence of volcanic ash conditions hazardous to flight. This extends the base SIGMET type by including additional information necessary for volcanoes and volcanic ash.

Attribute	***Multi-plicity***	***Type***	***Notes***
eruptingVolcano	[1]	Volcano	The volcano that is erupting

F.2.4 SIGMETEvolvingConditionAnalysis

Type: Class.

Notes: A specialized OM_Observation type used for reporting an aggregate set of meteorological conditions hazardous to flight over a large airspace, including anticipated characteristics. The result of this observation type refers to a single EvolvingMeteorologicalCondition which represents a SIGMET observation or forecast of meteorological conditions.


class Context Diagram: SIGMETEvolvingConditionAnalysis
The sampled feature for SIGMET is always an FIR, UIR, or CTA. The sampled feature is still present (but may be a link) when the entire FIR or CTA is affected by the phenomenon
SF_SpatialSamplingFeature
«FeatureType»
samplingSurface::
SF_SamplingSurface
+propert+featureOfInterest
1
0..*
«FeatureType»
SIGMETEvolvingConditionAnalysis
constraints
{self.featureOfInterest.sampledFeature.oclIsKindOf(Airspace)}
{self.featureOfInterest.result.oclIsKindOf(EvolvingMeteorologicalPosition)}
OM_Observation
«FeatureType»
Observation and Measurement Types::
SamplingObservation
Used for OBS and FCST conditions on all SIGMET reports
+result
«FeatureType»
EvolvingMeteorologicalCondition
+ directionOfMotion :Angle [0..1]
+ geometry :AirspaceVolume
+ intensityChange :ExpectedIntensityChange
+ speedOfMotion :Velocity
«enumeration»
ExpectedIntensityChange
NO_CHANGE
WEAKEN
INTENSIFY

F.2.5 EvolvingMeteorologicalCondition

Type: Class.

Notes: Conditions that indicate the presence of a specific SIGMET phenomenon such as volcanic ash or a thunderstorm, along with expected changes to the phenomenon such as intensity, speed, and direction. These conditions are reported with OBS/FCST conditions on all SIGMET types.

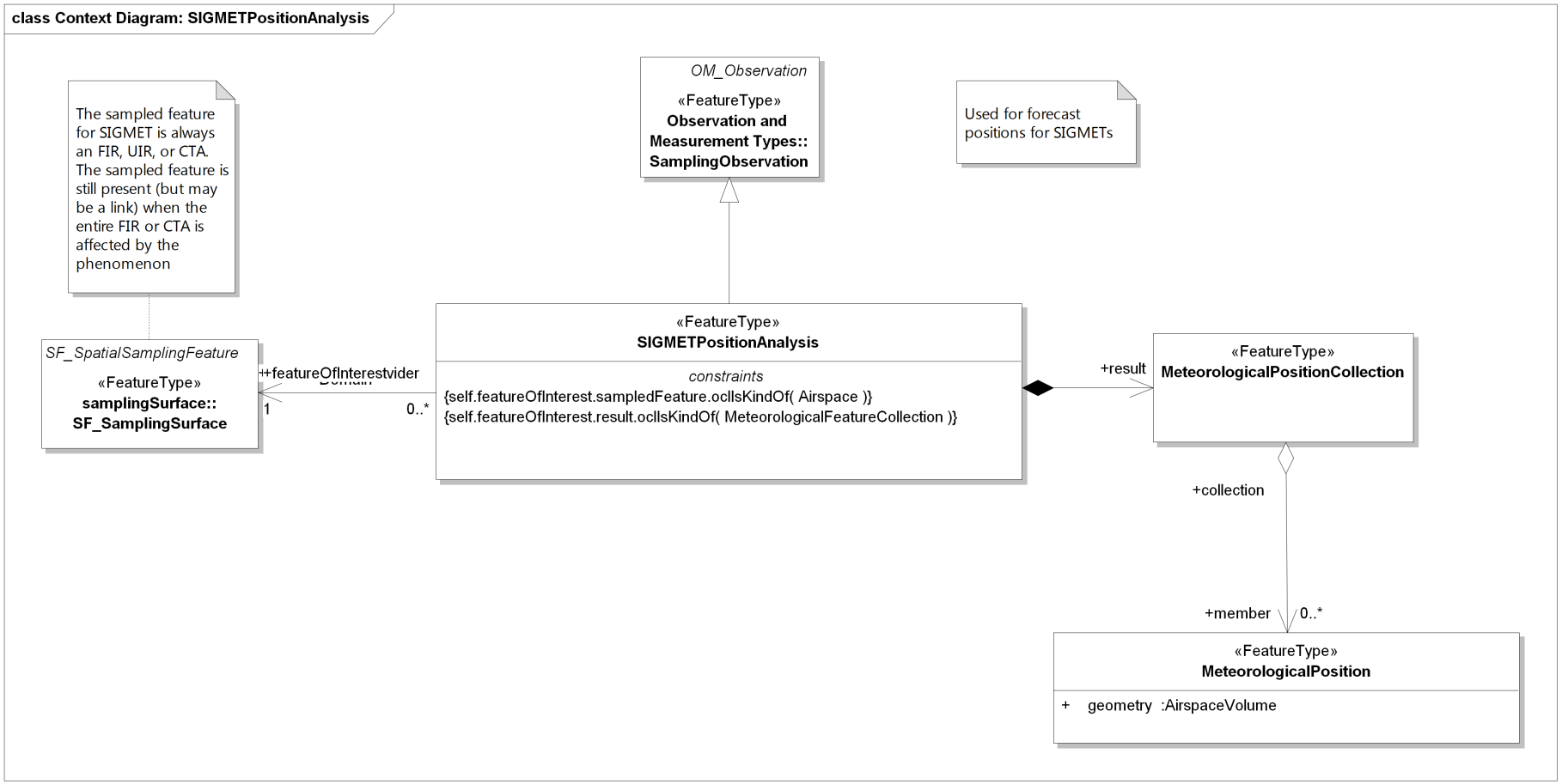
TC TOP (ABV and BLW) conditions are represented by the vertical component of the geometry. For example: CB TOP FL500 is represented as a missing lowerLimit and an upperLimit of 500FL.

Attribute	***Multi-plicity***	***Type***	***Notes***
directionOfMotion	[0..1]	Angle	The expected direction of movement of a meteorological condition. When no movement is expected, this is a http://www.opengis.net/def/nil/OGC/0/inapplicable nilReason and the speedOfMotion will be 0.
geometry	[1]	AirspaceVolume	The expected geographic region affected by the reported phenomenon at a particular time (thunderstorms, volcanic ash, etc.). This geometry covers all combinations of phenomenon historically reported in ICAO Annex 3 / WMO No. 49-2: a boundary with a base and top, a TC centre position, and a VA line with a width
intensityChange	[1]	ExpectedIntensityChange	The expected change in intensity for the reported meteorological condition (e.g., intensifying, weakening, or no change) determined at the time of SIGMET analysis based on the current state of the meteorological condition
speedOfMotion	[1]	Velocity	The expected speed of movement of a meteorological condition. When no movement is expected, this will have a value of 0 and directionOfMotion will have a http://www.opengis.net/def/nil/OGC/0/inapplicable nilReason.

F.2.6 SIGMETPositionAnalysis

Type: Class.

Notes: A specialized OM_Observation type used for reporting the forecast position of meteorological conditions hazardous to flight. The result of this observation type refers to one or more MeteorologicalPositions which represents the forecast positions of SIGMET phenomena.



F.2.7 MeteorologicalPositionCollection

Type: Class.

Notes: A collection of MeteorologicalPositions, each representing a location where meteorological conditions exist. All members of this collection are of type MeteorologicalPosition.

F.2.8 MeteorologicalPosition

Type: Class.

Notes: Conditions that indicate the presence of a specific SIGMET phenomenon such as volcanic ash or a thunderstorm. Used to represent the forecast positions of SIGMET phenomena.

TC TOP (ABV and BLW) conditions are represented by the vertical component of the geometry. For example: CB TOP FL500 is represented as a missing lowerLimit and an upperLimit of 500FL.

In cases where the position covers an entire FIR or CTA, ("ENTIRE CTA or ENTIRE FIR" from ICAO Annex 3 / WMO No. 49-2) the geometry should be an xlink to the sampled feature for this SIGMET.

Attribute	***Multi-plicity***	***Type***	***Notes***
geometry	[1]	AirspaceVolume	The geographic region affected by the reported phenomenon at a particular time (thunderstorms, volcanic ash, etc.). This geometry covers all combinations of phenomenon historically reported in Annex 3: a boundary with a base and top, a TC center position, and a VA line with a width

F.2.9 ExpectedIntensityChange

Type: Enumeration.

Notes: Expected change in intensity for (significant) meteorological phenomena.

See WMO No. 306 Vol I.2 Part B FM 94 BUFR code-table 0 20 028 'Expected change in intensity'.

Attribute	***Multi-plicity***	***Type***	***Notes***
NO_CHANGE	[1]		No change (NC)
WEAKEN	[1]		Forecast to weaken (WKN)
INTENSIFY	[1]		Forecast to intensify (INTSF)

F.2.10 SIGMETReportStatus

Type: Enumeration.

Notes: The status of a SIGMET report (e.g., a normal issuance, a cancellation of an earlier SIGMET)

Attribute	***Multi-plicity***	***Type***	***Notes***
NORMAL	[1]		A normal SIGMET report (not a cancellation)
CANCELLATION	[1]		A cancellation of an earlier SIGMET report

F.2.11 AeronauticalSignificantWeatherPhenomenon

Type: Class.

Notes: Weather phenomenon of significance to aviation operations; used in SIGMET and AIRMET reports. The set of permitted options are defined in ICAO Annex 3 / WMO No. 49-2 C.3.1 sub-clause 1.1.4

ANNEX G: ABRIDGED CLASS DEFINITIONS AND CONTEXT DIAGRAMS FOR THE ICAO METEOROLOGICAL INFORMATION EXCHANGE MODEL (IWXXM), COMMON

G.1 Introduction

The authoritative version of IWXXM is maintained within AvXML as an online resource at the following URL: http://wis.wmo.int/AvXML/AvXML-1.1/index.htm. (N.B.: There are no whitespace characters in the URL.) What follows is abridged to suit the needs of the print medium.

G.2 The Common leaf of IWXXM

Notes: The Common leave of the ICAO Meteorological Information Exchange Model (IWXXM) models common constructs used across multiple packages. This package includes constructs closely related to the aviation weather domain.

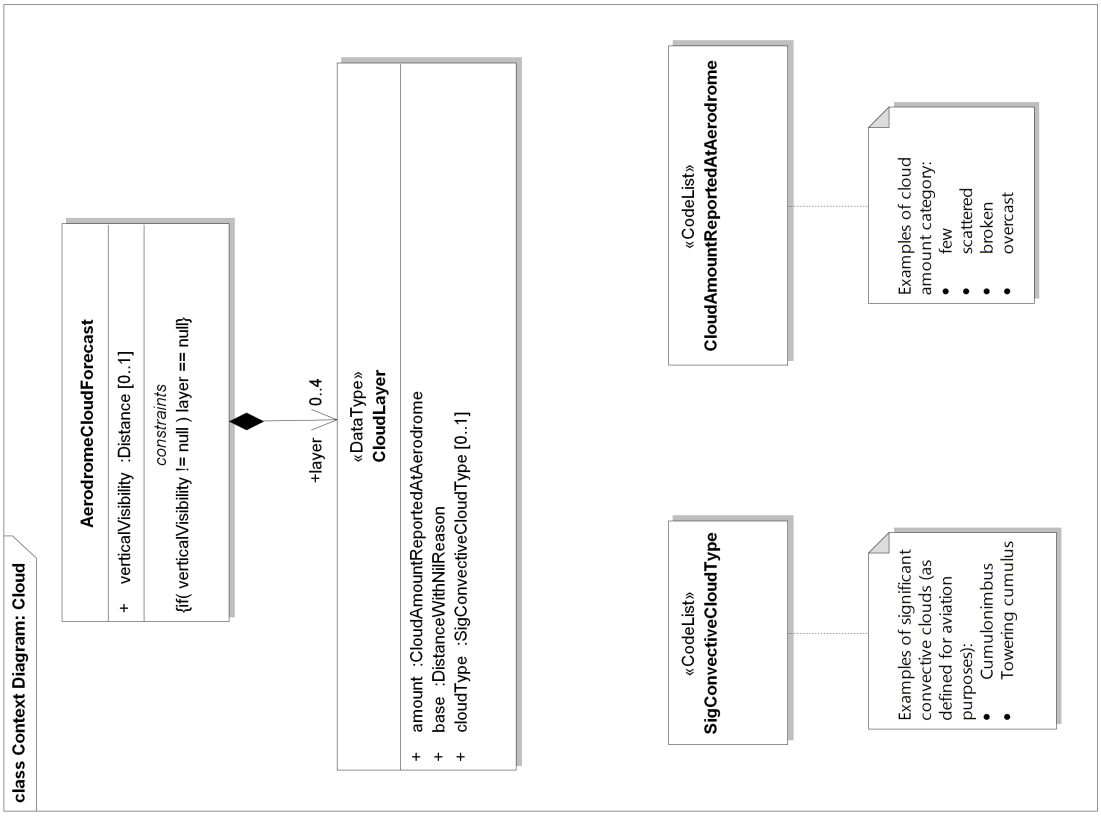
G.2.1 AerodromeCloudForecast

Type: Class.

Notes: Forecast cloud conditions, including predicted vertical visibility and cloud layers.

A single vertical visibility may be reported, but cannot be reported with cloud layers.

Attribute	***Multi-plicity***	***Type***	***Notes***
verticalVisibility	[0..1]	Distance	The vertical visibility. Vertical visibility is defined as the vertical visual range into an obscuring medium.


class Context Diagram: Cloud
AerodromeCloudForecast
+ verticalVisibility :Distance [0..1]
constraints
{if(verticalVisibility != null) layer == null}
+layer
0..4
«DataType»
CloudLayer
+ amount :CloudAmountReportedAtAerodrome
+ base :DistanceWithNilReason
+ cloudType :SigConvectiveCloudType [0..1]
«CodeList»
CloudAmountReportedAtAerodrome
Examples of cloud amount category:
• few
• scattered
• broken
• overcast
«CodeList»
SigConvectiveCloudType
Examples of significant convective clouds (as defined for aviation purposes):
• Cumulonimbus
• Towering cumulus

G.2.2 CloudLayer

Type: Class.

Notes: A cloud layer, including a cloud amount, cloud base and cloud type

Attribute	***Multi-plicity***	***Type***	***Notes***
amount	[1]	CloudAmountReportedAtAerodrome	The observed cloud amount
base	[1]	DistanceWithNilReason	For a given cloud or cloud layer, height of the lowest level in the atmosphere at which the air contains a perceptible quantity of cloud particles.
cloudType	[0..1]	SigConvectiveCloudType	The observed significant cloud types: cumulonimbus or towering cumulus

G.2.3 CloudAmountReportedAtAerodrome

Type: Class.

Notes: Amount of cloud – assessed by category.

This CodeList is specifically defined for aviation purposes, as defined in WMO No. 49-2. A superset of cloud-amount categories are defined in WMO No. 306 Vol I.2 FM 94 BUFR code-table 0 20 008 "Cloud distribution for aviation".

G.2.4 SigConvectiveCloudType

Type: Class.

Notes: Genus of cloud of operational significance to aviation: significant convective clouds only.

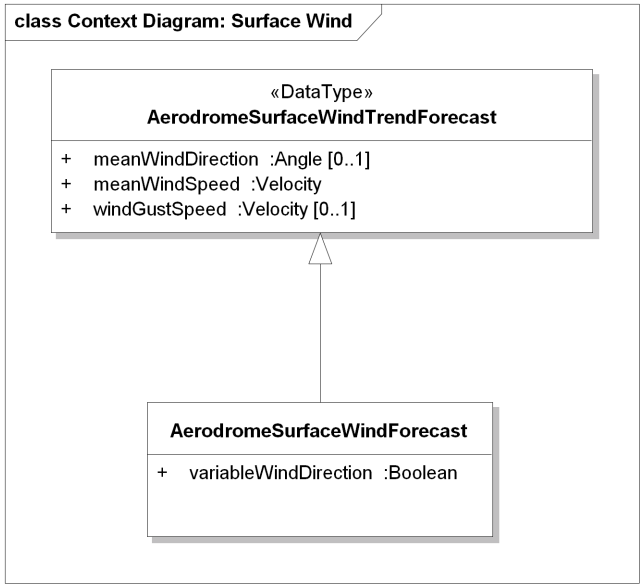
This CodeList is specifically defined for aviation purposes, as defined in WMO No. 49-2. A superset of definitions are defined in WMO No. 306 Vol I.2 FM 94 BUFR code-table 0 20 012 "Cloud type".

G.2.5 AerodromeSurfaceWindTrendForecast

Type: Class.

Notes: A trend forecast of surface wind conditions at an aerodrome.

Attribute	***Multi-plicity***	***Type***	***Notes***
meanWindDirection	[0..1]	Angle	The forecast average wind direction from which wind is blowing
meanWindSpeed	[1]	Velocity	The forecast average wind speed
windGustSpeed	[0..1]	Velocity	The forecast maximum speed of a gust.



G.2.6 AerodromeSurfaceWindForecast

Type: Class.

Notes: A forecast of wind conditions at an aerodrome.

This extends AerodromeSurfaceWindTrendForecast to allow for a variable wind direction to be reported. This class differs from a aerodrome wind observation in that the observations may include a min/max directional variability. This class only carries a true/false indication that it will be variable.

Attribute	***Multi-plicity***	***Type***	***Notes***
variableWindDirection	[1]	Boolean	Indicates variable wind direction. Cannot be reported with a mean wind direction

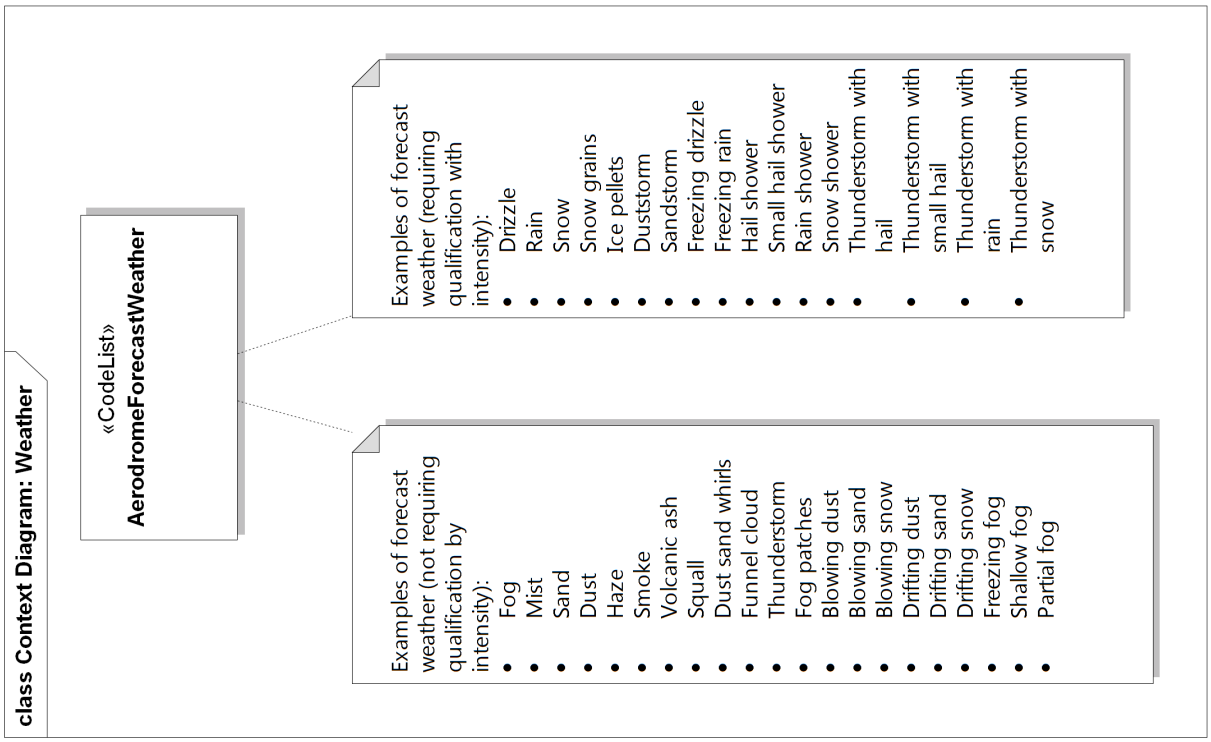
G.2.7 AerodromeForecastWeather

Type: Class.

Notes: AerodromeForecastWeather enables the forecast weather at an aerodrome to be reported.

Only a specific set of weather phenomenon are reported within aviation meteorology as defined in Regulation ICAO Annex 3 / WMO No. 49-2.

This ?CodeList? is specifically defined for aviation purposes as defined in WMO No. 49-2. A superset of definitions are defined in WMO No. 306 Vol I.1 code-table 4678 "Significant weather phenomena".


class Context Diagram: Weather
«CodeList»
AerodromeForecastWeather
Examples of forecast weather (not requiring qualification by intensity):
• Fog
• Mist
• Sand
• Dust
• Haze
• Smoke
• Volcanic ash
• Squall
• Dust sand whirls
• Funnel cloud
• Thunderstorm
• Fog patches
• Blowing dust
• Blowing sand
• Blowing snow
• Drifting dust
• Drifting sand
• Drifting snow
• Freezing fog
• Shallow fog
• Partial fog
Examples of forecast weather (requiring qualification with intensity):
• Drizzle
• Rain
• Snow
• Snow grains
• Ice pellets
• Duststorm
• Sandstorm
• Freezing drizzle
• Freezing rain
• Hail shower
• Small hail shower
• Rain shower
• Snow shower
• Thunderstorm with hail
• Thunderstorm with small hail
• Thunderstorm with rain
• Thunderstorm with snow

G.2.8 RelationalOperator

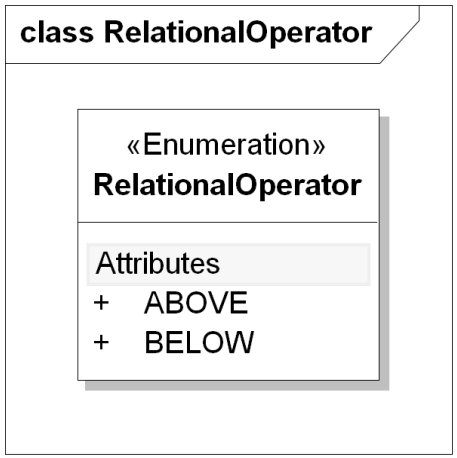
Type: Enumeration.

Notes: RelationalOperator defines the restricted set of operators that may be specified alongside numerical quantities in ICAO Annex 3/WMO No. 49.

These operators are used in cases where a precise value is not measurable, not precisely known due to measurement limitations, or not reported due to reporting restrictions.

For example, the "above" operator in conjunction with the reported quantity 10.6 indicates that the actual physical quantity is above 10.6 (at least 10.6).

Attribute	***Multi-plicity***	***Type***	***Notes***
ABOVE	[1]		The actual value is above the maximum value that can be determined by the system ("ABV", "P")
BELOW	[1]		The actual value is below the minimum value that can be determined by the system ("BLW", "M")



ANNEX H: METHODS FOR GENERATING DATA REPRESENTATIONS FROM UNIVERSAL MODELLING LANGUAGE (UML)

H.1 INTRODUCTION

TT_AvXML spent a substantial level of effort developing a repeatable set of “mostly automated” procedures that successfully generated XML schemas from UML. These procedures were presented at the first meeting of the WMO’s Inter-Programme Expert Team on Metadata and Data Representation Development (IPET-MDRD) as Discussion Paper D24. A subsequent paper, D25, presented information on alternatives to these procedures which were still in development. Both papers can be downloaded from the WMO website. D24 is at http://wis.wmo.int/file=903 and D25 is at http://wis.wmo.int/file=949.

Discussion Paper D24 of IPET-MDRD-1 follows in its entirety. Both papers refer to the process as a “serialization procedure.”

OVERVIEW OF SERIALIZATION PROCEDURE FROM APPLICATION SCHEMA (UML) TO GML SCHEMA (XML SCHEMA)

INTRODUCTION

1. TT-AvXML at its first meeting (TT-AvXML-1) considered it essential to have a tool to automatically transform the AvXML logical data model in UML into the corresponding physical model in XML to ensure consistency and integrity of the conversion products.

2. Historically, Enterprise Architect (EA) is being used for the development of the UML model and FullMoon has been chosen for the automatic transformation of the UML model into XML schema for AvXML.

3. For compatibility reasons, EA Version 9 Build 9.3.932 and FullMoon Version 2302 are being used for the transformation.

PRE-REQUISITES

1. EA with Solid Ground Toolset from CSIRO[1]. This provides ISO 191xx profiled UML elements to be used during modelling. This should be installed before development of the GML application or importing of the respective XMI file into EA.

2. FullMoon with patches and scripts developed by HKO. These fix a number of bugs, implement new transformation behaviour[2] and streamline transformation. An Oracle VirtualBox disk image containing FullMoon with the patches applied and associated script/software configured on Ubuntu is available.

3. Oxygen XML Developer, Apache Tomcat 6.0 and scripts developed by HKO for post-processing of XSD files generated.

PROCEDURES

1. Create GML application packages

   a) Import ISO TC 211 UML model in XMI format into EA. The latest version can be downloaded from the ISO/TC211 Harmonized Model Web server[3].

   b) Develop GML application packages on or import packages in XMI format into EA. Ensure that the packages complies with the ISO 19100 series Application Schema profile, in particular the GML stereotypes and tagged values should be appropriately set[4] (see Appendix A).

   c) Ensure that any class in the model has a dependent association to another model (see Figure 1). The process of creating these package associations can be automated through the use of Solid Ground function “Generate Package Dependencies Diagram”. Prior to using this function any existing package associations of the model should be deleted.

---

[1] See https://wiki.csiro.au/display/solidground/Solid+Ground+Toolset

[2] See Doc (13) of TT-AvXML-3 at http://wis.wmo.int/file=529 for details

[3] See http://www.isotc211.org/hmmg/EArchitect/

[4] Apart from the stereotypes and tagged values, there are also known problems if sequence numbers, directed associations and aggregations are not properly assigned.

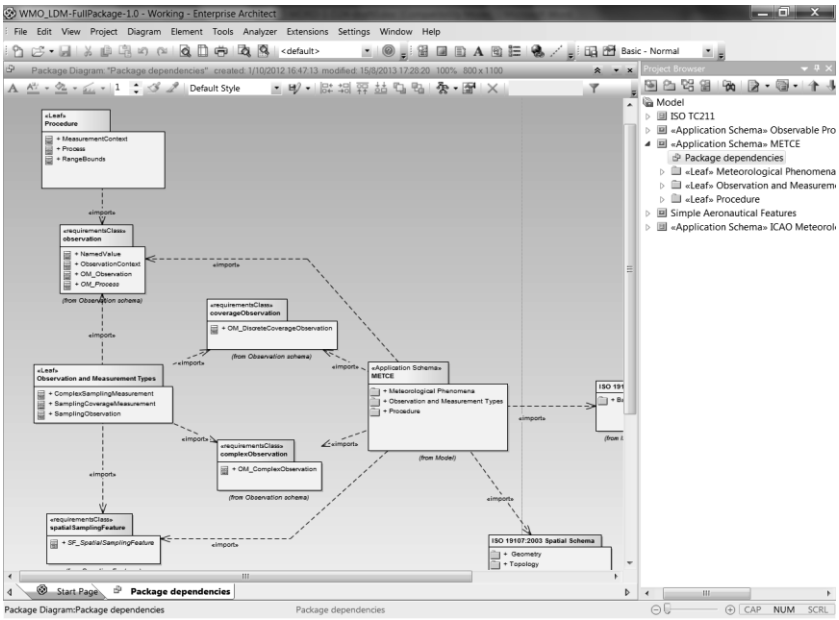


Figure 1

d) Publish model packages individually in XMI format with options (a) XML Type: UML 1.3 (XMI 1.1) and (b) General options: Export Diagrams, Format XML Output (see Figure 2). Confirm the code page in XML specifications is “utf-8” (see Figure 3).

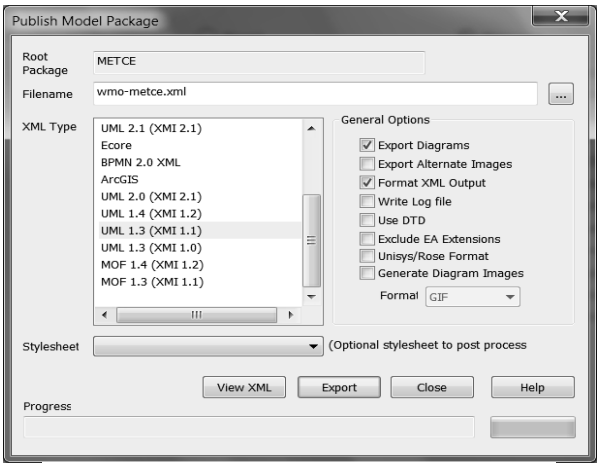


Figure 2

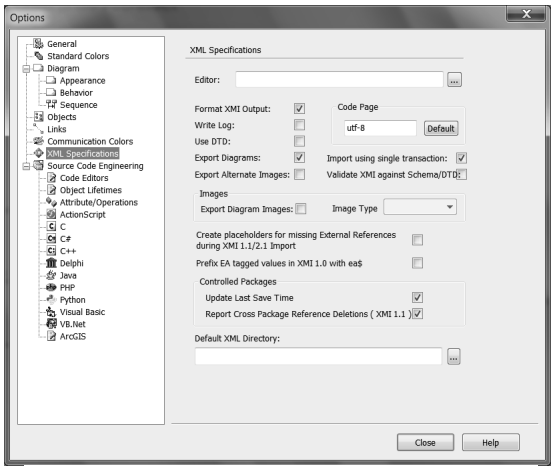


Figure 3

2. Transform the GML application packages

a) Copy the exported XMIs to the VirtualBox Virtual Machine. Edit the configuration file for the automation script as necessary.

(Using OPM of AvXML as an example)

- Copy the exported OPM XMI “wmo-opm.xml” to “/home/user/fullmoon_2302/resources/xmi-samples”
- Uncomment the parts corresponding to OPM in “/home/user/fullmoon_2302/deploy-config/properties/fullmoon.properties”
- Execute “cd /home/user/fullmoon_2302; ant deploy-all”

b) Confirm packages are in conformance to the (modified) standards with FullMoon's conformance test feature

> (Using OPM of AvXML as an example)
>
> - Execute "cd to /home/user/fullmoon_2302/bin; ant –f run.xml init-then-add; ant –f run.xml test"
> - The package conforms to the standards if output failed=0

c) In hierarchal order

i. Transform the package with FullMoon

> (Using OPM of AvXML as an example)
>
> - Execute "cd to /home/user/fullmoon_2302/bin; ant –f run.xml exec-enc-and-export-then-copy"
> - The output XSD files are located at "/home/user/Desktop/Schema-local"

ii. Create class map of the transformed output and feed into FullMoon if this package is required by subsequent packages

> (Using OPM of AvXML as an example)
>
> - Copy the XSD files from the virtual machine at "/home/user/Desktop/Schema-local" to "Drive:/Program Files/Apache Software Foundation/Tomcat 6.0/webapps/fullmoon-required/wmo/opm"
> - Drag "GenerateFromXSDV4.xsl" to the Oxygen XML Developer
> - Modify "target-process" variable to opm
> - Modify "classmap-location" path to Tomcat installation directory
> - Create a new XSLT scenario if not existed
> - XML URL: full path to "start.xml"
> - XSL URL: full path to "GenerateFromXSDV4.xsl"
> - Transformer: Saxon-HE x.x.x.x
> - Run the transformation
> - Copy "ClassMap_opm.xml" back to virtual machine "/home/user/apache-tomcat-6.0.36/webapps/fullmoon-required/ClassMaps/WMO"

iii. Repeat until all packages have been transformed

3. Post-process the resulting XSD files

a) Insert schematron rules into the XSD files

b) Apply other modifications to the XSD files, including a change of schema locations from local to global and other documentation changes

(Using OPM of AvXML as an example)

- Copy the directory containing XSD files "/home/user/Desktop/Schema-local" from the virtual machine to a place accessible by Oxygen XML Developer and renamed it to "Schema-local-emb-sch"
- Drag "schematron-mixV2.xsl" to Oxygen XML Developer
- Modify the path under CONFIG variables and point to folder "Schema-local-emb-sch"
- Create a new XSLT scenario if not existed
  - XML URL: full path to start.xml
  - XSL URL: full path to schematron-mixV2.xsl
  - Transformer: Saxon-HE x.x.x.x
- Run the transformation
- Repeat with other XSLT documents, viz:
  - "schematron-mixV2.xsl" (for injecting schematron and embedded schematron to xsds)
  - "appinfo-doc.xsl" (for injecting vocabulary, extensibility and quantity to documentation)
  - "correct_import.xsl" (for turning local schema to public schema)
  - "RemoveOMSub.xsl" (for replacing OMSub classes with "XXX and relevant components removed" in comment)
  - "AddDocumentation.xsl" (for adding "References to WMO and ICAO Tech…." documentation)
  - "self-close-fix.xsl" (for beautifing the empty tag to self-close tag)

RECOMMENDED TEXT

1. IPET-MDRD noted the procedures described in "Overview of Serialization Procedure from Application Schema (UML) to GML Schema (XML Schema)" (Doc 24) and asked the Secretariat to store this so that it was available to those developing future releases of the XML schemas.

ANNEX H APPENDIX A: UML STEREOTYPES AND TAGGED VALUES FOR GML APPLICATION SCHEMAS

Summary of GML stereotypes*

The first set of stereotypes corresponds primarily the set described in Table E.1 of ISO 19136:2007 (GML 3.2.1), and are suitable for a domain model that is ready for direct conversion to XML as a GML Application Schema.

Stereotype name	Scope	Use	XML Implementation
«Application Schema» «applicationSchema»	Package	Complete application schema	An XML Schema in a single XML namespace
«FeatureType» «featureType»	Class	Feature-type	XML element whose XML Schema-type is derived from gml:AbstractFeatureType
noStereotype «Type» «type»	Class	Referenceable objects other than features	XML element whose XML Schema-type is derived from gml:AbstractGMLType
«DataType» «dataType»	Class	Structured data type	XML element with a complex content model; does not have identity and must appear inline
«Union» «union»	Class	Arbitrary set of alternative classes	Choice group whose members are GML Objects or Features, or objects corresponding to DataTypes
«CodeList» «codeList»	Class	Extensible enumeration	Union of an enumeration of string values and a pattern
«Enumeration» «enumeration»	Class	Fixed enumeration	Enumeration of string values

* Extracted from SEE GRID Community website of CSIRO at https://www.seegrid.csiro.au/wiki/AppSchemas/UmlGmlStereotypesAndTaggedValues

Some additional stereotypes have been found useful in domain modelling. These are packaged as a separate "UML Profile" for use in the HollowWorld environment.

Stereotype name	Scope	Use	XML Implementation
«Leaf»	Package	Convenient group of elements within an application schema	Single XML Schema document
«PrimitiveType»	Class	Structured data type	Class which has a "canonical" pre-defined XML encoding
«property»	attribute, associationRole	property	local element (a) having a simple type (b) containing a complex type, or (c) using the GML in-line or by-reference pattern

A set of tagged-values is prescribed for each stereotype, to specify information required for the XML implementation derived from the model. See GML stereotypes and associated tagged values for more detail.

ISO GML stereotypes and associated tagged values*

NOTE: Tag usage is described in ISO 19136:2007 Annex E, except for *tags in italics which relate to proposed extensions to the standard*. **Tags in bold are mandatory**.

UML element	GML Application Schema implication	UML Tagged values
All elements		documentation=string
The first group of UML elements are related to packaging and namespaces		
Package	The default mapping is one W3C XML Schema document per package	targetNamespace=anyURI xmlns=NCName **xsdDocument=string** version=string
«Application Schema»	Components in a single XML Namespace	**targetNamespace=anyURI** **xmlns=NCName** **xsdDocument=string** version=string
«Leaf»	Components described in a single W3C XML Schema Document	**xsdDocument=string**
The second group of elements are classes carrying various stereotypes		
Classes in the first group are implemented as global XML Schema Type Definitions. They are used to define content models for XML elements representing simple properties		
«Enumeration»	Type defined as a restriction of W3C XML Schema string with enumeration values	

* Extracted from SEE GRID Community website of CSIRO at https://www.seegrid.csiro.au/wiki/AppSchemas/UmlGmlStereotypesAndTaggedValues

«CodeList»	Type defined as the union of an enumeration and a string *pattern* "other:value", or a reference to a dictionary *the tags in italics are mandatory for FullMoon processing when asDictionary=true*	asDictionary=boolean default="false" *codeSpace=anyURI* *dictionaryIdentifier=anyURI* *memberIdentifierStem=anyURI*
Classes in the next group are implemented as global XML Schema element declarations, supported by global XML Schema Type Definitions. The substitutionGroup affiliation is the element representing the parent class. Note: Abstract *classes have the abstract attribute set "true"*		
«DataType»	Global element with a complexType whose content model is normally implemented as a <sequence> of elements representing the properties	noPropertyType=boolean default="false" byValuePropertyType=boolean default="false"
«Type» or no stereotype	Global element with a complexType whose content model is a <sequence> of elements representing the properties. The type definition is immediately or transitively derived from AbstractGMLType, *else* if xmlSchemaType has a value it has a special implementation as the given XML Schema type	noPropertyType=boolean default="false" byValuePropertyType=boolean default="false" xmlSchemaType=QName
«FeatureType»	Global element with a complexType whose content model is a <sequence> of elements representing the properties. The type definition is immediately or transitively derived from AbstractFeatureType	noPropertyType=boolean default="false" byValuePropertyType=boolean default="false"

Other class types		
«Union»	Named choice-group whose members are GML Objects or Features, or objects corresponding to DataTypes	noPropertyType=boolean default="false"
Properties		
Attribute	Local element within the content model (i.e. the complexType definition) of a DataType, ObjectType or FeatureType * the name of the property is given by the attribute name * when the UML type of the attribute is a class stereotyped «Enumeration» or «CodeList», the type of the property element is the XML Schema type mapped to the attribute type or target class * when the UML type of the attribute is a class stereotyped «DataType», the property element has a complexType following the "inline" pattern described in GML 3.2 clause 7, that contains the element with the name of the target class * when the UML type of the attribute is a class stereotyped «Type» or «FeatureType», the property element has a complexType following the standard by-value or by-reference pattern described in GML 3.2 clause 7	inlineOrByReference=(inline,byReference,inlineOrByReference) default="inlineOrByReference" **sequenceNumber=integer** isMetadata=boolean default="false" *ownedBy=string*

Association end	Local element within the content model (i.e. the complexType definition) of a DataType, Type or FeatureType * the name of the property is given by the roleName on the target end of a navigable association * when the UML type of the association target is a class stereotyped «DataType», the property element has a complexType following the "inline" pattern described in GML 3.2 clause 7, that contains the element with the name of the target class * when the UML type of the association target is a class stereotyped «Type» or «FeatureType», the property element has a complexType following the standard by-value or by-reference pattern described in GML 3.2 clause 7	inlineOrByReference=(inline,byReference,inlineOrByReference) default="inlineOrByReference" **sequenceNumber=integer** isMetadata=boolean default="false" isCollection=boolean default="false" *ownedBy=string*

METCE GML stereotypes and associated tagged values

UML element	GML Application Schema implication	UML Tagged values

«CodeList»	Transformation serializes «CodeList» Type to XSD as:
	`<element name="{Class.Name}" type="{ApplicationSchema.xmlns}:{Class.Name}Type"/>`
	`<complexType name="{Class.Name}Type">`
	`  <annotation>`
	`  <appinfo>`
	`  <vocabulary>{Class.TaggedValues.vocabulary.value}</vocabulary>`
	`  <extensibility>{Class.TaggedValues.extensibility.value}</extensibility>`
	`  </appinfo>`
	`  <documentation>`
	`  {Class.Notes}`
	`  </documentation>`
	`  </annotation>`
	`  <complexContent>`
	`  <extension base="gml:ReferenceType"></extension>`
	`  </complexContent>`
	`</complexType>`
		xsdEncodingRule=
		”iso19136_2007_METCE_Extension”
		asDictionary=”true”
		vocabulary and extensibility are not empty

«Type» «DataType» «FeatureType»	Transformation serializes UML attributes of the types to XSD attribute as: `<attribute name="{Attribute.Name}" type="{Attribute.Type.Namespace}:{Attribute.Type}"/>`	xsdEncodingRule= ”iso19136_2007_METCE_Extension” xsdAsAttribute=”true”

«Type»
«DataType»
	Transformation serializes UML attributes of the types to XSD elements as:
	`<element name="{Attribute.Name}" type="{Attribute.Type.Namespace}:{Attribute.Type}">`
	`  <annotation>`
	`  <appinfo>`
	`  <quantity>{Attribute.TaggedValues.quantity.value}</quantity>`
	`  </appinfo>`
	`  <documentation>{Attribute.Notes}</documentation>`
	`  </annotation>`
	`</element>`
		xsdEncodingRule=
		”iso19136_2007_METCE_Extension”
		quantity not empty

«Type»	Transformation add “nilReason” attribute to the complexType as: `<attribute name="nilReason" type="gml:NilReasonType"/>`	xsdEncodingRule= ”iso19136_2007_METCE_Extension” Nillable=”true”

Recommendation 11 (CBS-Ext.(2014))

REVISED *MANUAL ON THE GLOBAL OBSERVING SYSTEM* (WMO-No. 544)

THE COMMISSION FOR BASIC SYSTEMS,

Noting the recent preparation of the Manual on the WMO Integrated Global Observing System (WIGOS),

Noting further the need to update and harmonize the information contained in the *Manual on the Global Observing System* (WMO-No. 544), Volume I – Global Aspects, with that contained in the Manual on WIGOS,

Considering the importance of the *Manual on the Global Observing System* in comprising part of the WIGOS Regulatory Material,

Recommends that Volume I – Global Aspects, of the Manual be replaced by the text contained in the annex to the present recommendation.

_____

Note: This recommendation replaces Recommendation 3 (CBS-15), which is no longer in force.

Annex to Recommendation 11 (CBS-Ext.(2014))

REVISED *MANUAL ON THE GLOBAL OBSERVING SYSTEM* (WMO-No. 544)

Volume I

(Annex V to WMO Technical Regulations)

Global Aspects

WMO-No. 544

~~2010~~ 2105 edition

~~UPDATED IN 2013~~

EDITORIAL NOTE

The following typographical practice has been followed: Standard practices and procedures have been printed in semi-bold roman. Recommended practices and procedures have been printed in light face roman. Notes have been printed in smaller type, light face roman, and preceded by the indication Note.

METEOTERM, the WMO terminology database, may be consulted at: http://www.wmo.int/pages/prog/lsp/meteoterm_wmo_en.html. Acronyms may also be found at: http://www.wmo.int/pages/themes/acronyms/index_en.html.

WMO-No. 544

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Date	*Part/chapter/section*	*Purpose of amendment*	*Proposed by*	*Approved by*
~~May 2013~~	~~Volume I, Part IV~~	~~Revision of the text on space-based subsystem proposed by the Commission for Basic Systems at its fifteenth session in 2013 and approved by the Executive Council at its sixty fifth session~~	~~CBS-15 Recommendation 3 (CBS-15)~~	~~EC-65 (Resolution 10 (EC-65))~~

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INTRODUCTION

PURPOSE AND SCOPE

1. The Manual is designed:
(a) To facilitate cooperation in observations between Members;
(b) To specify obligations of Members in the implementation of the World Weather Watch (WWW) Global Observing System (GOS);
(c) To ensure adequate uniformity and standardization in the practices and procedures employed in achieving (a) and (b) above.

2. The first edition of the *Manual on the Global Observing System* was issued in 1980 in accordance with the decisions of Seventh Congress. Since then it has undergone a number of revisions and amendments. ~~These have been consolidated into this new revised edition approved by Resolution 8 (EC-LV).~~ This 2015 edition marks the start of the transition of provisions across to the Manual on WIGOS (WMO-No. xxx) which will eventually replace the Manual on the GOS entirely. For now these two Manuals are companion documents and must be read in conjunction with each other. In particular the provisions of the Manual on WIGOS apply to all component observing systems including the GOS.

3. The Manual is composed of Volumes I and II, which contain the regulatory material for the global and regional aspects, respectively. The regulatory material stems from recommendations of the Commission for Basic Systems (CBS) and resolutions of regional associations, as well as from decisions taken by Congress (Cg) and the Executive Council (EC).

4. Volume I of the Manual – Global Aspects – forms part of the WMO Technical Regulations and is referred to as Annex V to the WMO Technical Regulations.

5. Volume II of the Manual – Regional Aspects – does not form part of the WMO Technical Regulations.

6. In essence, the Manual specifies what is to be observed where and when in order to meet the relevant *observational* requirements of Members. The *Guide to the Global Observing System* (WMO-No. 488) provides detailed guidance on how to establish, operate and manage networks of stations to make these observations. While some regulatory material concerning instruments and methods of observation is contained in a special short section of the Manual, a full description of how and with what observations are made is contained in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8). The *International Cloud Atlas* (WMO-No. 407) describes the classification of clouds. The subsequent step of how observations are to be reported and encoded is specified in the *Manual on Codes* (WMO-No. 306). Further guidance on observations for special applications is given in WMO publications such as the *Guide on Meteorological Observing and Information Distribution Systems for Aviation Weather Services* (WMO-No. 731), *Guide to Marine Meteorological Services* (WMO-No. 471), *Guide to Climatological Practices* (WMO-No. 100), *Guide to Agricultural Meteorological Practices* (WMO-No. 134) and various publications of the Global Atmosphere Watch Programme.

TYPES OF REGULATION

7. Volume I of the Manual comprises *standard* practices and procedures and *recommended* practices and procedures. The definitions of these two types are as follows:

The *standard* practices and procedures:
(a) Are those practices and procedures which it is necessary that Members follow or implement; and therefore
(b) Have the status of requirements in a technical resolution in respect of which Article 9 (b) of the Convention is applicable; and
(c) Are invariably distinguished by the use of the term *shall* in the English text and by suitable equivalent terms in the French, Russian and Spanish texts.

The *recommended* practices and procedures:
(a) Are those practices and procedures which it is desirable that Members follow or implement; and therefore
(b) Have the status of recommendations to Members to which Article 9 (b) of the Convention shall not be applied; and
(c) Are distinguished by the use of the term *should* in the English text (except where specifically otherwise provided by decision of Congress) and by suitable equivalent terms in the French, Russian and Spanish texts.

8. In accordance with the above definitions, Members shall do their utmost to implement the *standard* practices and procedures. In accordance with Article 9 (b) of the Convention and in conformity with the provisions of Regulation 128 of the General Regulations, Members shall formally notify the Secretary-General, in writing, of their intention to apply the “standard practices and procedures” of the Manual, except those for which they have lodged a specific deviation. Members shall also inform the Secretary-General, at least three months in advance, of any

change in the degree of their implementation of a “standard practice or procedure” as previously notified and of the effective date of the change.

9. With regard to the *recommended* practices and procedures, Members are urged to comply with these, but it is not necessary to notify the Secretary-General of non-observance.

10. In order to clarify the status of the various regulatory material, the *standard* practices and procedures are distinguished from the *recommended* practices and procedures by a difference in typographical practice, as indicated in the editorial note.

NOTES, ATTACHMENTS (VOLUME I) AND VOLUME II

11. Certain notes are included in the Manual for explanatory purposes. They do not have the status of the annexes to the WMO Technical Regulations.

12. A number of specifications and formats of observing practices and procedures are included in the Manual. Taking into account the rapid development of observing techniques and the increasing requirements of the WWW and other WMO programmes, these specifications, etc., are given in “attachments” to the Manual and do not have the status of the annexes to the WMO Technical Regulations. This will enable the Commission for Basic Systems to update them as necessary.

13. The words “shall” and “should” in the attachments, notes and Volume II have their dictionary meanings and do not have the regulatory character mentioned in paragraph 7 above.

PART I

GENERAL PRINCIPLES REGARDING THE ORGANIZATION AND IMPLEMENTATION OF THE GLOBAL OBSERVING SYSTEM

1. PURPOSE OF THE GLOBAL OBSERVING SYSTEM

1.1 The purpose of the Global Observing System (GOS) shall be to provide, from all parts of the globe and from outer space, high-quality standardized observations of the state of the atmosphere, land and ocean surface for the preparation of weather analyses, forecasts and warnings and for other applications in support of WMO programmes and related environmental programmes of other organizations.

1.2 The GOS should provide supplementary observations required internationally for special purposes, provided this would not be detrimental to achieving the primary purposes of the World Weather Watch (WWW).

2. ORGANIZATION AND DESIGN OF THE GLOBAL OBSERVING SYSTEM

2.1 The GOS shall be organized as part of the WWW, in conjunction with the Global Data-processing and Forecasting System (GDPFS) and the Global Telecommunication System (GTS).

2.2 The GOS shall be constituted as a coordinated system of methods, techniques and facilities for making observations on a worldwide scale and as one of the main components of the WWW, taking into account to the extent feasible the requirements of other international programmes.

2.3 The GOS shall consist of facilities and arrangements for making observations at stations on land and at sea, from aircraft, from environmental observation satellites and other platforms.

2.4 For convenience in the planning and coordinating of the system, taking into account various criteria for observational data requirements, the GOS shall be considered as composed of three levels: global, regional and national.

2.5 The GOS shall be designed as a flexible and developing system capable of continuous improvement, on the basis of the latest achievements of technological and scientific progress and in accordance with changing requirements for observational data.

2.6 The planning and coordination of the GOS shall be realized through recommendations of the WMO Commission for Basic Systems (CBS) and approved by the Executive Council, in consultation and coordination with Members, regional associations and other technical commissions concerned.

2.7 The GOS shall consist of two subsystems: the surface-based subsystem and the space-based subsystem.

2.8 The GOS surface-based subsystem shall be composed of surface synoptic land and sea stations, upper-air synoptic stations, climatological stations, agricultural meteorological stations, aircraft meteorological stations, aeronautical meteorological stations, research and special-purpose vessel stations and special stations as detailed in Part III, paragraph 1 (a) to (h) of this Manual.

2.9 The main elements of the GOS surface-based subsystem shall consist of networks of surface synoptic stations on land and at sea and upper-air and aircraft meteorological stations as detailed in Part III, paragraph 1 (a) to (c) of this Manual.

2.10 Other elements of the GOS surface-based subsystem shall consist of aeronautical meteorological stations, climatological stations, agricultural meteorological stations, research and special-purpose vessel stations and special stations as listed in Part III, paragraph 1 (d) to (h) of this Manual.

2.11 The GOS space-based subsystem shall comprise satellites of three types: operational low Earth orbit and operational geostationary satellites and research and development (R&D) satellites.

3. IMPLEMENTATION OF THE GLOBAL OBSERVING SYSTEM

3.1 All activities connected with the implementation of the GOS on the territories of individual countries should be the responsibility of the countries themselves and should, as far as possible, be met from national resources.

3.2 Implementation of the GOS on the territory of developing countries should be based on the principle of the utilization of national resources but, where necessary and so requested, assistance may be provided in part through:

(a) The WMO Voluntary Cooperation Programme (VCP);
(b) Other bilateral or multilateral arrangements including the United Nations Development Programme (UNDP) which should be used to the maximum extent possible.

3.3 Implementation of the GOS in regions outside the territories of individual countries (e.g. outer space, oceans, the Antarctic) should be based on the principle of voluntary participation of countries that desire and are able to contribute by providing facilities and services, either individually or jointly from their national resources, or by having recourse to collective financing. The assistance sources described in 3.2 above may also be used.

3.4 In the implementation of the GOS, maximum use should be made of existing arrangements, facilities and personnel.

Notes:

1. The setting up and operation of the new and improved facilities and services require a considerable amount of scientific research, development engineering, coordination of procedures, standardization of methods and implementation coordination.
2. The further development of the GOS is an important feature of the WWW plan that provides for:
   (a) Continued development of the GOS as a cost-effective composite system comprising operationally reliable surface-based and space-based (satellite) subsystems. It is expected that, within the surface-based subsystem, new systems measuring both large and local scales of atmospheric phenomena will be deployed operationally on a wider scale. Increasing use will be made of the rapidly growing fleet of aircraft with automated observing and reporting systems to supply observation of data at cruising levels and during ascent and descent. Mobile sea stations will continue to be the main source for surface synoptic observations over the oceans. Through increased use of automatic observing and (satellite) transmission equipment, the quality and quantity of the data will increase. The number of ships equipped with automated upper-air sounding facilities (within the Automated Shipboard Aerological Programme (ASAP)) will increase and the deployment of more cost-effective systems will be accelerated. Drifting buoys, deployed outside the main shipping routes, will continue to supply surface atmospheric and oceanographic parameters from the data-void ocean areas. It is also expected that the operational space-based subsystem will include a new generation of polar-orbiters and geostationary satellites with improved and new sensing systems.
   (b) Coordination, integration and sustainability of composite surface- and space-based subsystems and development of observing networks that are adaptable to changing requirements. This will include the planning for a new composite upper-air observing system making the most effective use of new and emerging technology, in order to develop a cost-effective, truly global system with the density of in situ observations required for operational purposes as well as to complement and calibrate observations from satellites. The new composite system will utilize a range of technologies and techniques some of which could become operational only after a long-term development effort. The introduction of new technology should be as and when proven and must be consistent with existing systems and supporting structures.
   (c) Development of new strategies to facilitate closer cooperation between Meteorological Services and research programmes so that the available observing systems and programmes can be of use to operational meteorology and the research community.
   (d) Exploring new ways for Members to contribute to the GOS, including joint funding and innovative arrangements to ensure adequate observations in remote and data-sparse areas.

3.5 Existing elements of the GOS, as defined in Part III, shall not be removed before the reliability of a new element has been proven, and relative accuracy and representativeness of the observational data have been examined and found acceptable.

PART II

REQUIREMENTS FOR OBSERVATIONAL DATA

Note: regulatory material regarding the requirements for observational data from the GOS is contained in the Manual on WIGOS (WMO-No. xxx)

1. REQUIREMENTS IN SPECIAL CIRCUMSTANCES~~CLASSIFICATION OF REQUIREMENTS~~

~~Note:A classification of the scales of meteorological phenomena is given in Attachment II.1.~~

~~1.1 Global requirements~~

~~Global requirements shall refer to observational data needed by Members for a general description of large-scale and planetary-scale meteorological phenomena and processes.~~

~~1.2 Regional requirements~~

~~Regional requirements shall be related to the observations needed by two or more Members to describe in greater detail the large- and planetary-scale atmospheric phenomena, as well as to describe the smaller ones on the mesoscale and small scale as may be agreed by regional associations.~~

~~1.3 National requirements~~

~~National requirements shall be determined by each individual Member in the light of its own interests.~~

~~1.4 Application area observational requirements~~

~~Observational data requirements for specific application areas such as Global Numerical Weather Prediction, Nowcasting and Very Short Range Forecasting, etc. are defined, reviewed and updated as part of the Rolling Review of Requirements (RRR) Process as described in the *Guide to the Global Observing System* (WMO-No. 488).~~

1.~~5~~1 Special requirements for environmental emergency response activities

In order for the designated Regional Specialized Meteorological Centres (RSMCs) to be in a position to provide Members with transport model products for environmental emergency response, meteorological and non-meteorological (radiological) data requirements need to be met. They are specified in Attachment II.~~2~~1. These data, particularly from the site of an accident, are also needed by Members so that they may take appropriate preventive and remedial action in case of an accidental release of radioactive material into the environment. Data should be made available promptly in accordance with the Convention on Early Notification of a Nuclear Accident (Article 5 (e)).

1.~~6~~2 Requirements in the event of volcanic activity

Requirements in the event of volcanic activity potentially hazardous to aviation should be related to the observational data needed by Members for taking appropriate action; these data are specified in Attachment II.~~3~~2.

~~2. PROCEDURE FOR ELABORATION OF REQUIREMENTS~~

~~2.1 The formulation of observational data requirements is a complicated process which consists of several stages. At various levels this process involves groups of end-users, regional associations, WMO technical commissions and other bodies. In order to rationalize the formulation of the observational data requirements, the following procedures (schematically shown in Figure II.1) are applied. The process is called the Rolling Review of Requirements (RRR) Process and is described in detail in the Guide to the Global Observing System (WMO-No. 488).~~

~~2.2 Users present to WMO Members their needs for observational data for various application areas (e.g. meteorological services for aviation, marine navigation, industry, agriculture, climate research, etc.). Meteorological data might be used in two ways: directly in the provision of meteorological services, and in the preparation of meteorological products (weather analysis and prognoses) by Global Data-processing and Forecasting System (GDPFS) centres. In the latter case, GDPFS centres are considered as users.~~

~~2.3 WMO technical commissions are responsible for the consolidation of data needs presented by Members and for the formulation, on their basis, of a statement on observational data requirements/goals (usually in the form of tables) in various WMO Programmes. This should include explanatory notes and a rationale for the requirements/goals and, if possible, a statement on the incremental value of partially meeting these goals (in terms~~

~~of accuracy, density, frequency, etc.). Often this will include a feedback process with users to ensure that enough information and understanding about users' needs are available. If a statement on requirements/goals is addressed to the World Weather Watch, and in particular to its Global Observing System, it should be presented to the Commission for Basic Systems (CBS) for consideration.~~

~~2.4 The Commission for Basic Systems:~~

~~(a) Evaluates the feasibility of stated requirements/goals. The evaluation of technical and instrumental feasibility should be conducted in collaboration with the Commission for Instruments and Methods of Observation (CIMO), the WMO body responsible for the Instruments and Methods of Observation Programme (IMOP). The evaluation process will result in the formulation (in the form of tables) of what portion of the statement of requirements/goals is feasible and can be achieved. As part of the RRR Process, a Statement of Guidance will be prepared to indicate the feasibility of achieving the stated requirements;~~

~~(b) Formulates system requirements to provide observational data to meet the requirements/goals defined by the technical commissions;~~

~~(c) Develops any amendments to the WMO regulatory and guidance publications on the basis of system requirements and submits them (in case of regulatory publications) to the Executive Council.~~

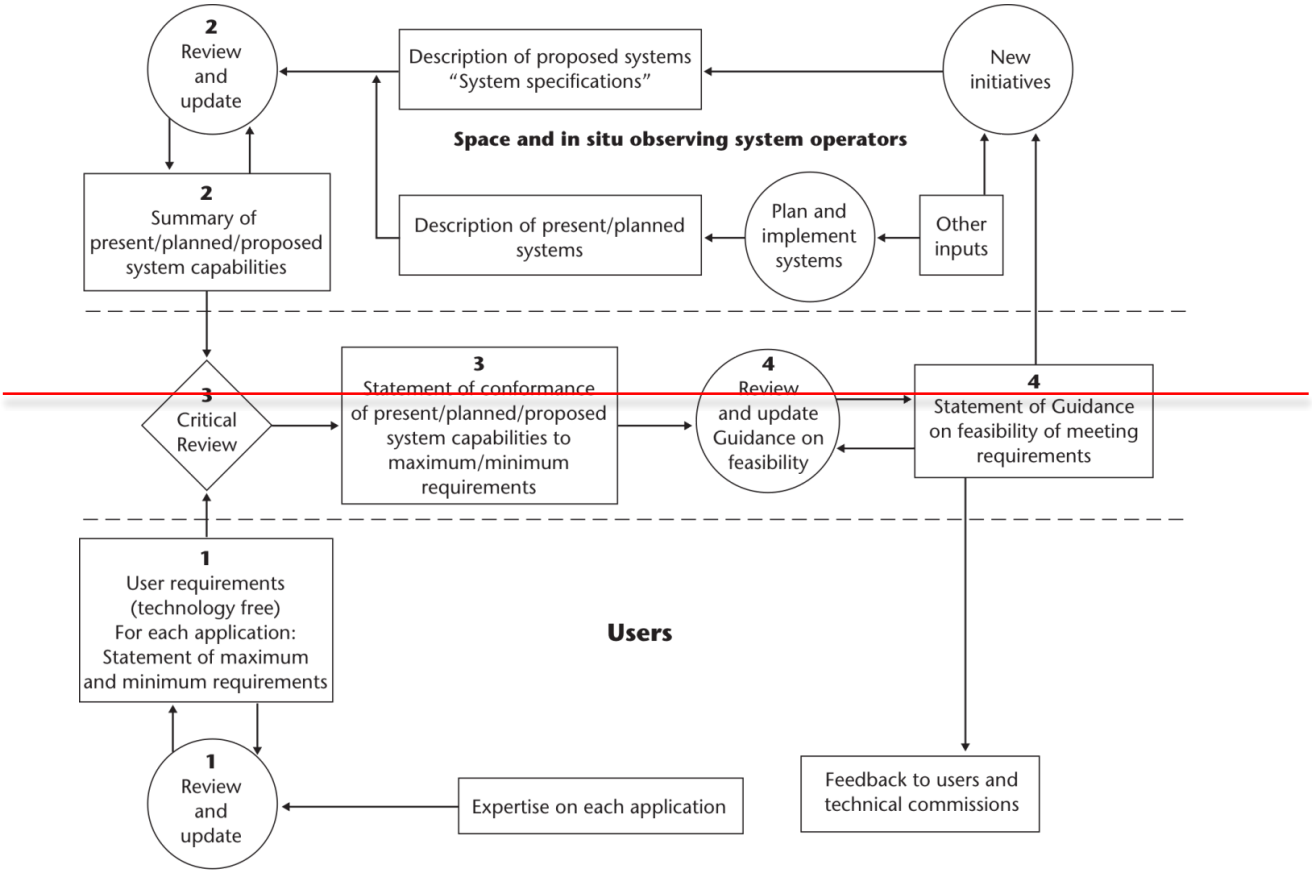
~~Note:The primary responsibility for the evaluation of the feasibility of meeting stated observational data requirements related to the Global Atmosphere Watch, and for the development of associated guidance material, rests with the Commission for Atmospheric Sciences.~~

~~2.5 The Executive Council approves the amendments and requests the Secretary-General to incorporate them in appropriate WMO Manuals.~~

~~2.6 The Members will be advised on the performance of observing systems and programmes through updated WMO Manuals and Guides to meet users' needs for observational data.~~

~~3. SYSTEMS FOR MEETING REQUIREMENTS~~

~~The surface-based subsystem and the space-based subsystem shall complement each other in providing the observational data required.~~



Note: The four stages of the Rolling Requirements Review process are 1, 2, 3 and 4.

~~Figure II.1. Rolling Review of Requirements Process~~

~~ATTACHMENT II.1~~

~~CLASSIFICATION OF SCALES OF METEOROLOGICAL PHENOMENA~~

~~The horizontal scales of meteorological phenomena can be classified as follows:~~
~~(a) Microscale (less than 100 m for agricultural meteorology; for example, evaporation);~~
~~(b) Toposcale or local scale (100 m–3 km), for example air pollution, tornadoes;~~
~~(c) Mesoscale (3 km–100 km; for example, thunderstorms, sea and mountain breezes);~~
~~(d) Large scale (100–3 000 km, for example, fronts, various cyclones, cloud clusters);~~
~~(e) Planetary scale (larger than 3 000 km, for example long upper tropospheric waves).~~

~~Note:The requirements for observational data shall be determined in part by these scales of meteorological phenomena. Many phenomena overlap between two of the classes indicated, and there is also dynamic interaction between the phenomena in different scales.~~

~~Scale (d) should be considered as roughly corresponding to the regional level within the World Weather Watch (WWW), and (d) and (e) can be combined within the global level.~~

ATTACHMENT II.~~2~~1

SPECIAL OBSERVATIONAL REQUIREMENTS FOR ENVIRONMENTAL EMERGENCY RESPONSE ACTIVITIES

A. METEOROLOGICAL DATA REQUIREMENTS

1. Data needed to run transport models are the same as specified for the production of weather forecasts based on numerical weather prediction (NWP) models and are given in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), Volume I – Global Aspects, Appendix II.2 and the *Guide to the Global Observing System* (WMO-No. 488), Appendix II.1.

2. Additional data[1] are desirable from the accident site[2] and potentially affected area[3] and should be available to the designated Regional Specialized Meteorological Centre (RSMC) to improve the quality of information about the transport of pollutants. These should include:
(a) Wind, temperature and humidity, upper-air data;
(b) Precipitation data (type and amount);
(c) Surface air temperature data;
(d) Atmospheric pressure data;
(e) Wind direction and speed (surface and stack height) data;
(f) Humidity data.

3. The data needed from the accident site may be provided by the following systems in combination as necessary and possible:
(a) At least one radiosonde station should be located at a suitably safe distance to enable continued operation in an emergency situation and to be representative of conditions at or near the accident site;
(b) In an emergency situation, at two or three stations closest to the site of the accident (within 500 km) frequency should be increased to every three hours for the duration of the emergency. Stocks of consumables should be stored for use in emergency situations;
(c) At least one surface station should be located at the accident site or, if not possible, at a nearby site. It should be convertible to an hourly automated mode for both operations and telecommunications in case of emergency;

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[1] The words “additional data” are used with their usual meaning and not as in Resolution 40 (Cg-XII).

[2] Due to the highly variable types of nuclear accidents, a precise definition of “accident site” is not possible. The accident site should be understood as the location where the accident occurred and the immediate surrounding zone within a range of a few kilometres.

[3] The potentially affected area is dependent on the state and evolution of the atmosphere over an extended area around the accident site, as well as on the nuclear event itself, and cannot be precisely defined in advance. It should be understood as the area where, using all the information available including the air transport pollution products if already issued, the nuclear pollutants are likely to be transported in the air or on the ground at a significant level over the natural (background) radioactivity. Advice in this area may be obtained from the RSMC concerned.

(d) Additional information should be provided at or near the accident site by instrumented towers or masts (up to 100 m) and conventional or Doppler radars, Sodars and boundary layer sondes with automatic transmission of data.

4. The data needed from the potentially-affected area should be provided as follows:
(a) All upper-air stations within the potentially-affected area should make observations every six hours of the emergency;
(b) Where possible, one or more additional observing systems, including wind profilers, mobile radiosounding equipment, and ascent/descent data from aircraft should be provided;
(c) All surface stations within the potentially-affected area including those which are not normally exchanged data internationally on a routine basis should provide observational data to designated RSMCs. Platforms and buoys should also provide observational data to ensure adequate coverage over sea areas;
(d) A series of best estimates of precipitation should be made by combining information from direct measurements (automated or manual) of surface stations, composite radar information extending over the whole WMO Region, and satellite-derived data.

B. NON-METEOROLOGICAL DATA REQUIREMENTS

1. In case of emergency, non-meteorological data to be provided to designated RSMCs from the accident site should include:
(a) Start of release (date, time);
(b) Duration;
(c) Radionuclide species;
(d) Total release quantity or pollutant release rate;
(e) Effective height of release.

Points (a) and (b) are necessary information for running transport models, while (c), (d) and (e) are desirable additional information.

2. In order to calibrate and validate the atmospheric transport model forecasts processed, radiological data from potentially affected areas are needed. The most suitable radiological data required are:
(a) Time-integrated air pollutant concentration;
(b) Total deposition.

3. The required data from the accident site and potentially-affected area may be obtained by the following means:
(a) Fixed radiological monitoring stations;
(b) Mobile surface units;
(c) Radiological sounding/or;
(d) Instrumental aircraft.

The frequency of observations should be increased from one hour to 10 minutes during the accident (routine frequency of observations varies from one to six hours).

C. EXCHANGE OF METEOROLOGICAL AND NON-METEOROLOGICAL DATA

1. Non-meteorological data and, to some extent, additional meteorological data are likely to be provided by non-meteorological national authorities. The National Meteorological or Hydrometeorological Services (NMSs) should encourage the provision of these data by non-meteorological agencies/operators to National Meteorological Centres (NMCs) for onward transmission to their associated RSMCs.

2. For the exchange of relevant meteorological and non-meteorological (radiological) data, a complete list of abbreviated heading bulletins, including all the regional meteorological and radiological observations, should be sent by Members to the WMO Secretariat for insertion into *Weather Reporting* (WMO-No. 9), Volume C1 – Catalogue of Meteorological Bulletins.

3. Radiological data available in the early phase of a nuclear accident (containment radiation reading, on-site radiation levels, etc.) which assist in characterizing the nuclear accident, should be provided by national authorities to the International Atomic Energy Agency (IAEA) as soon as practicable via the most reliable communication means. The IAEA will verify and assess the information and then provide these data to the appropriate RSMC, which should distribute them to NMCs via the Global Telecommunication System (GTS). In case of environmental emergencies, all relevant observational (meteorological and non-meteorological) data should be transmitted to both RSMCs and NMSs through the GTS as quickly as possible.

4. End-to-end testing of procedures for data acquisition, quality control, communication use and product dissemination should be carried out periodically to assure system performance.

ATTACHMENT II.~~3~~2

OBSERVATIONAL REQUIREMENTS IN THE EVENT OF VOLCANIC ACTIVITY

The International Airways Volcano Watch (IAVW) is coordinated and developed by the International Civil Aviation Organization (ICAO) Secretariat with the assistance of the Volcanic Ash Warnings Study Group. The *Handbook on the International Airways Volcano Watch (IAVW)* (ICAO Doc 9766) describes the operational procedures and the contact list for the implementation of the IAVW in the event of the occurrence of pre-eruption volcanic activity,[4] volcanic eruptions and volcanic ash clouds.

A. METEOROLOGICAL DATA REQUIREMENTS

The data needed to run transport models are the same as specified for the production of weather forecasts based on numerical weather prediction (NWP) models and are given in the *Manual on the Global Data-Processing and Forecasting System* (WMO-No. 485), Volume I – Global Aspects, Appendix II.1~~2~~ and the *Guide to the Global Observing System* (WMO-No. 488), Appendix II.I.

1. Additional data[5] are desirable from the area in the vicinity of the volcano and should be made available to the designated Meteorological Watch Offices and Volcanic Ash Advisory Centre (VAAC)[6] to improve the quality of information about the transport of volcanic ash. These data are the same as specified for the special observation requirements for environmental emergency response activities and are given in Attachment II.~~1~~2 of this Manual.

2. Imagery data from geostationary and polar-orbiting satellites are required by the designated VAAC to ascertain whether a volcanic ash cloud is identifiable and to determine its extent (vertical and horizontal) [Reference: The *Handbook on the International Airways Volcano Watch* (*IAVW*), Section [4.1.1 (c)] and Section 4.5.1 (b)]. These data are also required to validate the transport model trajectory forecast and to determine when the volcanic ash has dissipated. The imagery data should:
(a) Be multi-spectral covering visible and infrared wavelengths;
(b) Have adequate spatial resolution to detect small volcanic ash clouds (5 km or less);
(c) Have global coverage to provide data for all the VAACs;
(d) Have a frequent repeat cycle (30 minutes or less for the detection of volcanic ash and at least every six hours for tracking volcanic ash for transport model validation) [Reference: *Handbook on the International Airways Volcano Watch* (*IAVW*), Section 4.4.1 (c), Section 4.5.1 (d) and (e)];
(e) Be processed and delivered to the VAAC with a minimal delay.

3. Additional satellite data that can assist in the detection of pre-eruption volcanic activity, a volcanic eruption, or a volcanic ash cloud should be made available to the designated VAAC. This may include satellite data that can be used to detect volcanic hot-spots or sulphur dioxide emissions.

4. Data obtained from surface-based radar within range of the volcano should be made available to the designated VAAC. These data can be used to detect the presence of a volcanic ash cloud and measure its height.

B. NON-METEOROLOGICAL DATA REQUIREMENTS

1. The occurrence of pre-eruption volcanic activity, volcanic eruptions and volcanic ash clouds, because of the potential hazard to aviation, should be reported without delay to the designated Area Control Centres, Meteorological Watch Offices and VAAC as described in the *Handbook on the Inter-national Airways Volcano Watch* (*IAVW*). The report in plain language should be made in the form of a volcanic activity report comprising the following information, if available, in the order indicated:

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4 Pre-eruption volcanic activity in this context means unusual and/or increasing volcanic activity, which could presage an eruption.

5 The words “additional data” are used with their usual meaning and not as in Resolution 40 (Cg-XII).

6 Volcanic Ash Advisory Centres (VAACs) are designated by the International Civil Aviation Organization (ICAO) and WMO to issue advisories on the presence and forecasted trajectory of volcanic ash.

(a) Message type, VOLCANIC ACTIVITY REPORT;
(b) Station identifier, location indicator or name of station;
(c) Date/time of message;
(d) Location of volcano and name if known;
(e) Concise description of event including, as appropriate, level of intensity of volcanic activity, occurrence of an eruption and its date and time, the existence of a volcanic ash cloud in the area with the direction of ash cloud movement and height as best estimated.

2. Available geological data that indicates the occurrence of pre-eruptive volcanic activity or a volcanic eruption should be passed immediately to the designated Area Control Centres, Meteorological Watch Offices and VAAC [Reference: *Handbook on the International Airways Volcano Watch (IAVW)*, Section 4.1.1 (a)]. These data include:
(a) Vulcanological observations;
(b) Seismological activity reports.

3. Pilot reports of pre-eruption volcanic activity, volcanic eruptions and volcanic ash clouds should be reported without delay to the designated Area Control Centres, Meteorological Watch Offices and VAAC [Reference: *Handbook on the International Airways Volcano Watch (IAVW)*, Section 4.1.1 (a)].

C. EXCHANGE OF METEOROLOGICAL AND NON-METEOROLOGICAL DATA

The exchange of all the above data is described in the *Handbook on the International Airways Volcano Watch (IAVW)*.

PART III

SURFACE-BASED SUBSYSTEM

1. COMPOSITION OF THE SUBSYSTEM

The main elements of the surface-based subsystem are:

(a) Surface synoptic stations:
  (i) Land stations:
    – Manned surface stations;
    – Automatic surface stations;*
  (ii) Sea stations:
    – Fixed sea stations:
      – Ocean weather stations;
      – Lightship stations;
      – Fixed platform stations;
      – Anchored platform stations;
      – Island and coastal stations;
    – Mobile sea stations:
      – Selected ship stations;
      – Supplementary ship stations;
      – Auxiliary ship stations;
      – Ice-floe stations;
    – Automatic sea stations:*
      – Fixed sea stations;
      – Lightship stations;
      – Mobile sea stations;
      – Drifting buoy stations;
      – Moored buoy stations;

(b) Upper-air synoptic stations:
  – Rawinsonde stations;
  – Radiosonde stations;
  – Radiowind stations;
  – Pilot-balloon stations;

(c) Aircraft meteorological stations;

Other elements of the subsystem are:

(d) Aeronautical meteorological stations;
(e) Research and special-purpose vessel stations;
(f) Climatological stations;
(g) Agricultural meteorological stations;
(h) Special stations, which include:
  (i) Weather radar stations;
  (ii) Radiation stations;
  (iii) Wind profilers;
  (iv) Atmospherics detection stations;
  (v) Meteorological reconnaissance aircraft stations;
  (vi) Meteorological rocket stations;
  (vii) Global Atmosphere Watch stations;
  (viii) Planetary boundary-layer stations;
  (ix) Tide-gauge stations.

Notes:
1. Definitions of stations listed above will be found in the Appendix to this Manual.
2. Any station may fall under more than one of the above categories.
3. Observations from automatic surface synoptic stations on land or at sea may be asynoptic when collected via satellite.

~~* Data may be asynoptic when collected via satellite.~~

2. IMPLEMENTATION OF ELEMENTS OF THE SUBSYSTEM

2.1 Networks of observing stations

2.1.1 General

2.1.1.1 Corresponding to the three levels of requirements for observational data, three types of networks of observing stations – global, regional and national – shall be established.

2.1.1.2 The networks should be interdependent with selected stations of the national networks within a Region comprising the corresponding regional network, and with selected stations of the regional network forming the global network. Therefore, a station of the global network is part of a regional network and a national network.

2.1.1.3 The frequency and spacing of the observations should be adjusted to the physical scales of the meteorological phenomena to be described.

Note:See the *Guide to the Global Observing System* (WMO-No. 488), Figure II.1.

2.1.2 Global networks

2.1.2.1 A global synoptic network shall be established, based upon the Regional Basic Synoptic Networks (RBSNs).

Note:See 2.1.3 below.

2.1.2.2 The observing programme of the global synoptic network should provide meteorological data which have the necessary accuracy, spatial and temporal resolutions to describe the state of temporal and spatial changes in the meteorological phenomena and processes occurring on the large and planetary scales.

Note:Guidance as to the determination of requirements for accuracy and time and spatial resolution of the observational data is given in the *Guide to the Global Observing System* (WMO-No. 488).

2.1.2.3 The global synoptic network should be as homogeneous and as uniform as possible all over the globe, and the observations should be made at the main standard times of observation.

2.1.2.4 Members should implement and sustain the Global Climate Observing System (GCOS) Surface Network (GSN) – the global ~~reference~~baseline network of some 1 000 selected surface observing stations established to monitor daily global and large-scale climate variability.

2.1.2.5 Members should implement and sustain the GCOS Upper-air Network (GUAN) – the global baseline network of about ~~150~~ 170 selected upper-air stations established with relatively homogenous distribution to meet requirements of GCOS.

2.1.2.6 Members should ~~implement~~also establish and sustain the GCOS Reference Upper-Air Network (GRUAN) of about 30 to 40 selected upper-air stations, to provide long-term high quality climate records, to constrain and calibrate data from more spatially-comprehensive global observing systems (including satellites and current radiosonde networks), and to fully characterize the properties of the atmospheric column.

~~2.1.2.7 Members should also establish a network of Global Atmosphere Watch (GAW) stations designed to meet the need for monitoring, on a global and regional basis, the chemical composition and related characteristics of the atmosphere.~~

~~Note:For further information on the location of GAW stations, see the Technical Regulations (WMO-No. 49), Volume I – General Meteorological Standards and Recommended Practices, Part II, 2.4.3, Note 3, as well as the appropriate Global Atmosphere Watch technical publications, and the Guide to the Global Observing System (WMO-No. 488).~~

2.1.3 Regional networks

2.1.3.1 Regional networks shall be established in relation to the regional requirements.

Note:Regional associations are responsible for the determination and coordination of the composition of these networks within the general framework established by the Commission for Basic Systems (CBS).

2.1.3.2 Regional Basic Synoptic Networks of both surface and upper-air stations and Regional Basic Climatological Networks (RBCNs) of climatological stations shall be established to meet the requirements laid down by the regional associations.

Notes:
1. The regional associations will continue to examine their plans to meet any new international requirements.
2. Details of known regional requirements are given in Volume II of this Manual.

2.1.3.3 Together, the RBSNs shall form the main part of the global surface-based synoptic network.

2.1.3.4 Members shall implement the RBSNs.

2.1.3.5 The horizontal spacing of observing stations and the frequency of their reporting should be in accordance with the requirements laid down in Volume I, Part II, and Volume II of this Manual.

2.1.4 National networks

National networks shall be established by Members to satisfy their own requirements. When implementing these national networks, Members shall take into account the needs to complete the global and regional networks.

Note:A complete list of all surface and upper-air stations in operation which are used for synoptic purposes is given in *Weather Reporting* (WMO-No. 9), Volume A – Observing Stations.

2.2 Observing stations

General

2.2.1 The implementation and operation of each of the above elements should be as laid down by decisions of Congress, the Executive Council, the technical commissions and regional associations concerned.

Note:These decisions are reflected in the *Technical Regulations* (WMO-No. 49) and its annexes, for example this Manual and the *Manual on Codes* (WMO-No. 306), and in other relevant WMO publications such as the *Guide to the Global Observing System* (WMO-No. 488) and the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) which set forth the technical and meteorological aspects in detail.

2.2.2 In implementing the Global Observing System (GOS) surface-based subsystem, Members should ensure that the observing system meets the requirements placed on the subsystem.

2.2.3 In implementing the surface-based sub-system, Members should strive to meet the provisions indicated in 2.2.1 above as closely as possible, in particular as regards the main elements of the surface-based subsystem.

2.2.4 Each station should be located at a site that permits correct exposure of the instruments and satisfactory non-instrumental observations.

2.2.5 In general, observing stations shall be spaced at an interval and with observations taken frequently enough to permit an accurate description of the atmosphere for users of the observations for the purpose intended.

2.2.6 If in certain desert and other sparsely populated areas it is not possible to establish networks with the recommended densities, networks with densities as near as possible to those recommended should be established. Special efforts should be made to establish an adequate network in such an area when it borders a populated area or is traversed by a regularly used air route.

2.2.7 Asynoptic observations should be taken when necessary to ~~supplement~~ complement observations from the synoptic networks and in a manner which increases the overall observational ~~their~~ spatial or temporal ~~frequency~~density.

2.2.8 Observations should be taken in areas where special phenomena are occurring or expected to develop. As many meteorological elements of standard observations as possible should be reported. Information should be communicated in real time.

Note:Drifting buoys and aircraft may also report at asynoptic times.

2.2.9 Members shall ensure that a record of all surface and upper-air observations is made and preserved.

2.3 Surface synoptic stations

2.3.1 General

2.3.1.1 Surface synoptic stations may be manned or partly or fully automated and shall include land stations and fixed and mobile sea stations carrying out synoptic observations.

2.3.1.2 Each synoptic station shall be located so as to give meteorological data representative of the area in which it is situated.

2.3.1.3 The main standard times for surface synoptic observations shall be 0000, 0600, 1200 and 1800 UTC.

2.3.1.4 The intermediate standard times for surface synoptic observations shall be 0300, 0900, 1500 and 2100 UTC.

2.3.1.5 Atmospheric pressure observations should be made at exactly the standard time while the observation of other meteorological elements should be made within the 10 minutes preceding the standard time.

2.3.1.6 Every effort should be made to obtain surface synoptic observations four times daily at the main standard times, with priority being given to the 0000 and 1200 UTC observations, required for global exchanges.

2.3.1.7 Additionally, Members should endeavour to obtain surface synoptic observations at the intermediate standard times and, furthermore, at regular hourly intervals.

2.3.1.~~7~~8 When it is difficult for any reason to provide sufficient staff for 24-hour operations, partially or fully automated stations should ~~supplement~~ complement or replace manned surface stations including those in the basic synoptic network to provide observations at least at the main standard times.

2.3.2 Land stations

General

2.3.2.1 A synoptic station on land shall be identified by a station index number assigned by the Member concerned within the allocations made to that Member, in compliance with the scheme prescribed in the *Manual on Codes* (WMO-No. 306). Before issuing a station index number, Members should ensure that the operator of the station or platform has committed to complying with the relevant Technical Regulations.

Note:In circumstances where the station is outside the geographical area of any Member or the relevant Member is not able to assign a number, the Secretary-General may assist the process of assigning a number.

2.3.2.2 When a Member establishes a synoptic station on land ~~(or a fixed weather station at sea)~~ the Member shall send the following information to the Secretariat at least two months before the station becomes operational:
(a) Name, and where appropriate, station index number (stating whether the station is automatic or manned and, if both, the type of each);
(b) Geographical coordinates in degrees, minutes and integer seconds of arc and elevation of the station, in metres (up to two decimals) above mean sea level;
(c) Geopotential of the datum level in whole metres to which the pressure is reduced, or the reference isobaric surface the geopotential of which is reported;
(d) Times at which synoptic observations are made and reported;
(e) Topographical situation;
(f) Any other information required for completion of the entries in *Weather Reporting* (WMO-No. 9), Volume A – Observing Stations.

Note:Information on the accurate specification of the geographical coordinates and elevation of a station is provided in the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8), Part I, Chapter 1, 1.3.3.2.

2.3.2.3 Members shall send the necessary amendments to the information supplied under 2.3.2.2 (a) – (f) above to the Secretariat as soon as possible.

2.3.2.4 Any change in index number of synoptic stations included in the international exchanges should be notified to the Secretariat at least six months before becoming effective.

2.3.2.5 Each Member should publish a description~~, in sufficient detail to enable departures from the representativeness of observations to be assessed,~~ of each of its synoptic stations ~~whose reports are included in international exchanges~~in accordance with the provisions of the Manual on WIGOS (WMO-No. xxx).

2.3.2.6 All changes in the station index number of a synoptic station shall be effective from 1 January or 1 July each year.

2.3.2.7 Each Member of WMO shall designate a national focal point to communicate with the WMO Secretariat on matters regarding the contents of *Weather Reporting* (WMO-No. 9), Volume A – Observing Stations. The national focal point shall be authorized to act in these matters on behalf of the Permanent Representative concerned.

Location and composition

2.3.2.8 Surface land stations, including those in the RBSN, should be spaced at intervals not exceeding the minimum horizontal resolution required by applications areas supported by the network and as described in the Rolling Review of Requirements Process. During the first decade of the twenty-first century, the interval, in general, should not exceed 250 km (or 300 km in sparsely populated areas).

2.3.2.9 Surface synoptic observations recorded at a manned synoptic land station shall consist of observations of the following meteorological elements:
(a) Present weather;
(b) Past weather;
(c) Wind direction and speed;
(d) Cloud amount;
(e) Type of cloud;
(f) Height of cloud base;
(g) Visibility;
(h) Air temperature;
(i) Humidity;
(j) Atmospheric pressure;

together with such of the following meteorological elements as are determined by regional association resolutions:
(k) Pressure tendency;
(l) Characteristic of pressure tendency;
(m) Extreme temperature;

(n) Amount of precipitation;
(o) State of ground;
(p) Direction of cloud movement;
(q) Special phenomena.

2.3.2.10 A surface synoptic observation at an automatic land station shall consist of observations of the following meteorological elements:
(a) Atmospheric pressure;
(b) Wind direction and speed;
(c) Air temperature;
(d) Humidity;
(e) Precipitation, yes or no (at least in tropical areas);

together with the following meteorological elements which should be included if possible:
(f) Amount of precipitation;
(g) Intensity of precipitation;
(h) Visibility;
(i) Optical extinction profile (height of cloud base);*
(j) Special phenomena.

Notes:
1. The standard set of metadata elements is presented in Attachment III.1.
2. Height of cloud base and cloud extent could be derived directly from the optical extinction profile without further measurement, using one-minute time series.

Frequency and timing of observations

2.3.2.11 At synoptic land stations the frequency of surface synoptic observations should be made and reported eight times per day at the main and intermediate standard times in extratropical areas and four times per day at the main standard times in the tropics.

2.3.2.12 At a (manned or automatic) land station, surface synoptic observations shall be made and reported at least at the main standard times.

2.3.3 Sea stations

General

2.3.3.1 When more economical means are not available, ocean weather stations and some other fixed sea stations should provide essential and detailed meteorological and oceanographic data from critical locations or ocean areas.

Notes:
1. In this role, these stations are an integral part of regional and national networks.
2. Fixed sea stations also provide reference level data and a basis for calibration of soundings by remote sensing from satellites and are thus important in the analysis of phenomena on a large or planetary scale.
3. A fixed sea station other than an ocean weather station or a moored buoy may be identified by a station index number if considered to be in the same category as a land station.

2.3.3.2 Members shall recruit as mobile ship stations as many ships as possible that traverse data-sparse areas and regularly follow routes through areas of particular interest.

2.3.3.3 Members concerned shall provide the Secretariat, not later than 1 March each year, with a list of their selected and supplementary ship stations in operation at the beginning of the year or with amendments to the previous list giving the name, call sign and route or route designator of each ship.

2.3.3.4 Members shall include in the lists of selected and supplementary ship stations information on the method of obtaining sea surface temperature, type of barometer, psychrometer, barograph, radio equipment and other instruments aboard the ship and radiowatch hours.

2.3.3.5 Members should consider using fixed or mobile automatic sea stations or drifting buoy stations in the data-sparse areas ~~of persistent cloudiness, where remote sounding by satellite is hampered~~.

Note:These stations are located on fixed or mobile ships, fixed or anchored platforms and on drifting platforms and ice floes.

~~* Height of cloud base and cloud extent could be derived directly from the optical extinction profile without further measurement, using one-minute time series.~~

~~2.3.3.6 Environmental data buoy stations shall be identified by the International Identifier System.~~

~~Note:This identifier system is used by the Intergovernmental Oceanographic Commission and WMO universally.~~

Location and composition

2.3.3.~~7~~6 Each fixed sea station should be located so as to provide data which are representative of the marine area. As a minimum, observations should be taken at the main synoptic times. The observations should include as many meteorological elements of a full synoptic report as possible.

2.3.3.7~~8~~ Members should establish, either individually or jointly, ocean weather stations or other suitable observing facilities in ocean areas where there are large gaps in the global network.

Note: Information describing the station should be sent to the Secretariat as for synoptic land stations (see paragraph 2.3.2.2).

2.3.3.8~~9~~ In its recruitment programme, each Member should aim at making the maximum possible contribution from mobile sea stations towards attaining an adequate density of observations in all oceanic areas.

Note:An adequate density of surface reports in oceanic areas is one per 250 km.

2.3.3.9~~10~~ It shall be possible to determine the position of a fully automated mobile sea station.

2.3.3.10~~1~~ At ocean weather stations, a surface synoptic observation shall consist of observations of the following elements:
(a) Present weather;
(b) Past weather;
(c) Wind direction and speed;
(d) Cloud amount;
(e) Type of cloud;
(f) Height of cloud base;
(g) Visibility;
(h) Air temperature
(i) Humidity;
(j) Atmospheric pressure;
(k) Pressure tendency;
(l) Characteristic of pressure tendency;
(m) Ship's course and speed;
(n) Sea surface temperature;
(o) Direction of movement of waves;
(p) Wave period;
(q) Wave height;
(r) Sea ice and/or icing of ship superstructure, when appropriate;
(s) Special phenomena.

2.3.3.11~~2~~ At a selected ship station, a surface synoptic observation should consist of observations of elements (a) to (r) in 2.3.3.11 above.

2.3.3.12~~3~~ At a supplementary ship station, a surface synoptic observation should consist of observations of elements (a) to (h), (i) and (r) in 2.3.3.11 above.

2.3.3.13~~4~~ At an auxiliary ship station, a surface synoptic observation should consist of observations of elements (a) to (d), (g), (h) (j) and (r) in 2.3.3.11 above.

2.3.3.14~~5~~ At a lightship, a manned platform, and coastal and island stations, a surface synoptic observation should consist of observations of elements (a) to (r), with the exception of (m), in 2.3.3.11 above.

2.3.3.15~~6~~ At a fixed automatic sea station, surface synoptic observations shall consist of observations of the following elements:
(a) Atmospheric pressure;
(b) Wind direction and speed;
(c) Air temperature;
(d) Sea surface temperature;

In addition to the elements listed above, a surface synoptic observation made at a fixed automatic sea station should include, if possible, the following elements:
(e) Precipitation, yes or no (especially in tropical areas);
(f) Waves.

2.3.3.16~~7~~ At a drifting automatic sea station (drifting buoy), a surface synoptic observation should consist of as many as possible of elements (a) to (d) and (f) in 2.3.3.16 above.

Note:The position of the drifting buoy shall also have to be determined.

2.3.3.17~~8~~ Members should endeavour to equip mobile ships to make subsurface observations ~~and report them in the BATHY/TESAC code form~~.

Note:Guidance on steps to be taken while recruiting a selected, supplementary or auxiliary observing ship, on the organization needed to collect ships' weather reports and on the use of marine meteorological logs on board ships, is contained in the *Guide to Marine Meteorological Services* (WMO-No. 471).

Frequency and timing of observations

2.3.3.18~~9~~ At an ocean weather station, surface synoptic observations shall be made and reported at least four times per day and preferably hourly at the main and intermediate standard times.

2.3.3.19~~20~~ At lightship stations, fixed and anchored platform stations, and at automatic sea stations, surface synoptic observations shall be made and reported at least four times per day at the main standard times.

2.3.3.20~~1~~ At a mobile sea station, surface synoptic observations should be made and reported at least four times per day at the main standard times.

2.3.3.21~~2~~ When operational difficulties on board ship make it impracticable to make a surface synoptic observation at a main standard time, the actual time of observation should be as near as possible to the main standard time.

2.3.3.22~~3~~ Whenever storm conditions threaten or prevail, surface synoptic observations should be made and reported from a mobile sea station more frequently than at the main standard times.

2.3.3.23~~4~~ When sudden and dangerous weather developments are encountered at sea stations, surface observations should be made and reported as soon as possible without regard to the standard time of observation.

Note:For specific instructions relative to the furnishing by ships of special reports, in accordance with the International Convention for Safety of Life at Sea, see *Weather Reporting* (WMO-No. 9).

2.3.3.24~~5~~ Members should arrange for timely transmission of observations.

Note:Details of observing and reporting programmes are described in the *Guide to Marine Meteorological Services* (WMO-No. 471), Chapter 5. In case of difficulties resulting from fixed radiowatch hours on board single-operator ships, the procedures given in the *Manual on the Global Telecommunication System* (WMO-No. 386), Volume I – Global Aspects, Part I, Attachment I-1, should be followed.

2.4 Upper-air synoptic stations

General

2.4.1 Upper-air synoptic stations shall be identified as provided under 2.3.2.1 to 2.3.2.7 above.

2.4.2 The standard times of upper-air synoptic observations shall be 0000, 0600, 1200 and 1800 UTC.

2.4.3 As upper-air data from the ocean areas are particularly sparse, Members should give consideration to equipping suitable ships to make soundings and, if possible, to measure upper winds.

2.4.4 In the tropics, priority should be given to upper-wind observations.

2.4.5 Upper-air stations making observations of pressure, temperature, humidity and wind should be spaced at intervals not exceeding the minimum horizontal resolution required by applications areas supported by the network and as described in the Rolling Review of Requirements Process. During the first decade of the twenty-first century, the interval, in general, should not exceed 250 km or 1 000 km in sparsely populated and ocean areas.

Location and composition

2.4.6 An upper-air synoptic observation shall consist of observations of one or more of the following meteorological elements:
(a) Atmospheric pressure;
(b) Air temperature;
(c) Humidity;
(d) Wind direction and speed.

Frequency and timing of observations

2.4.7 At an upper-air synoptic station, the frequency of synoptic observations should be four per day at the standard times of upper-air synoptic observations.

2.4.8 At an upper-air synoptic station, upper-air observations shall be made and reported at least at 0000 UTC and 1200 UTC.

2.4.9 At ocean weather stations, upper-air synoptic observations should comprise rawinsonde observations at 0000 and 1200 UTC and/or radiowind observations at 0600 and 1800 UTC.

2.4.10 The actual time of regular upper-air synoptic observations should be as close as possible to (H-30) and should not fall outside the time range (H-45) to H.

Note:The actual time of a pilot-balloon observation may deviate from the range indicated above if, by doing so, wind observations to considerably greater heights can be expected.

2.4.11 In areas where it is not possible to meet the frequency requirements mentioned above, every effort should be made to obtain at least the following observations:
(a) Upper-air observations from the RBSNs and other networks of stations on land and at sea, twice daily, at 0000 and 1200 UTC;
(b) In the tropics, at stations where two complete radiosonde/radiowind observations are not made, priority should be given to the implementation of one complete radiosonde/radiowind observation and one radiowind observation daily.

2.5 Aircraft meteorological stations

General

2.5.1 Each Member shall arrange for observations to be made by aircraft of its registry operating on international air routes and for the recording and reporting of these observations.

Note:Further information on aircraft observations and reports may be found in the *Technical Regulations* (WMO-No. 49), Volume II – Meteorological Service for International Air Navigation, Part 1, [C.3.1.] 5.

2.5.2 Members accepting responsibility for collecting aircraft reports for synoptic purposes shall promptly make these available, in agreed code forms, to other Members.

2.5.3 Members should give special consideration to the use of an automated aircraft meteorological observing and reporting system.

2.5.4 Aircraft reports shall, at a minimum, satisfy the requirements of International Air Navigation (for details see the *Technical Regulations* (WMO-No. 49), Volume II – Meteorological Service for International Air Navigation, Part 1, [C.3.1.] 5).

Location and composition

2.5.5 The following aircraft observations shall be made:
(a) Routine aircraft observations during en-route and climb-out phases of the flight; and
(b) Special and other non-routine aircraft observations during any phase of the flight.

2.5.6 Routine air reports shall contain the following meteorological elements:
(a) Air temperature;
(b) Wind direction and speed;
(c) Turbulence;
(d) Aircraft icing;
(e) Humidity (if available).

In addition, reports of any volcanic activity observed by the flight crew shall be included.

2.5.7 Special aircraft reports shall be made whenever any of the following conditions are observed:
(a) Severe turbulence;
(b) Severe icing;
(c) Severe mountain wave;
(d) Thunderstorms, with or without hail, that are obscured, embedded, widespread or in squall lines;
(e) Heavy duststorm or heavy sandstorm;
(f) Volcanic ash cloud;
(g) Pre-eruption volcanic activity or a volcanic eruption;

In addition, in the case of transonic and super-sonic flights:
(h) Moderate turbulence;
(i) Hail;
(j) Cumulonimbus clouds.

2.5.8 Routine aircraft observations should be made at the designated air traffic services/meteorological (ATS/MET) reporting points.

Note:Lists of designated ATS/MET reporting points are prepared by and available from International Civil Aviation Organization (ICAO) Regional Offices.

Frequency and timing of observations

2.5.9 When automated observing and reporting systems are available, routine observations should be made every 15 minutes during the en-route phase and every 30 seconds during the first 10 minutes of the flight.

2.5.10 When voice communications are used, routine observations shall be made during the en-route phase in relation to those air traffic services reporting points or intervals:
(a) At which the applicable air traffic services procedures require routine position reports; and
(b) Which are those separated by distances corresponding most closely to intervals of one hour of flying time.

2.5.11 Observations shall be made by all aircraft of meteorological conditions encountered during the take-off or approach phases of flight, not previously reported to the pilot-in-command, which in his opinion are likely to affect the safety of other aircraft operations.

2.5.12 Observations shall also be made by aircraft:
(a) If a meteorological office providing meteorological service for a flight makes a request for specific data; or
(b) By agreement between a Meteorological Authority and an operator.

2.6 Aeronautical meteorological stations

General

2.6.1 Members should establish an adequate network of aeronautical meteorological stations to meet the requirements of aviation.

Note:Detailed information on aeronautical meteorological stations, observations and reports is given in the *Technical Regulations* (WMO-No. 49), Volume II – Meteorological Service for International Air Navigation, Part 1, [C.3.I.] 4.

2.6.2 The data relating to the elevation of an aeronautical meteorological station on land shall be specified in whole metres.

2.6.3 An aeronautical meteorological station on land shall be identified by a station index number assigned by the Member concerned in compliance with the scheme prescribed in Annex II of the WMO Technical Regulations – *Manual on Codes* (WMO-No. 306), Volume I.

2.6.4 If a change of index number of an aeronautical meteorological station on land, the reports of which are included in international exchanges, is necessary, such change should be made effective on 1 January or 1 July each year.

Location and composition

2.6.5 Aeronautical meteorological stations shall be established at aerodromes and other points of significance to international air navigation.

2.6.6 Aeronautical observations should consist of the following meteorological elements:
(a) Surface wind direction and speed;
(b) Visibility;
(c) Runway visual range, when applicable;
(d) Present weather;
(e) Cloud amount, type and height of base;
(f) Air temperature;
(g) Dew point temperature;
(h) Atmosphere pressure (QNH and/or QFE);
(i) Supplementary information.

Note:For further information on what is to be reported under “supplementary information”, see the *Technical Regulations* (WMO-No. 49), Volume II – Meteorological Service for International Air Navigation, Part 1, [C.3.I.] 4.6.8.

Frequency and timing of observations

2.6.7 Routine observations shall be made at intervals of one hour or, if so determined by regional air navigation agreement, at intervals of one half-hour. Special observations shall be made in accordance with criteria established by the Meteorological Authority in consultation with the appropriate Air Traffic Services Authority.

2.7 Research and special-purpose vessel stations

General

2.7.1 Members operating research and special-purpose vessels should do their utmost to ensure that all such vessels make meteorological observations.

Location and composition

2.7.2 In addition to as many as possible of the meteorological elements of surface and upper-air observations, subsurface temperature observations, down to the thermocline, should also be made and transmitted (in real time), in accordance with the procedures agreed between WMO and the Intergovernmental Oceanographic Commission.

Frequency and timing of observations

2.7.3 In addition to meeting requirements for research, special-purpose vessels should, when possible, make surface and upper-air observations that meet and supplement basic synoptic requirements.

2.8 Climatological stations

General

2.8.1 Each Member shall establish in its territory a network of climatological stations.

2.8.2 The network of climatological stations should give a satisfactory representation of the climate characteristics of all types of terrain in the territory of the Member concerned (e.g. plains, mountainous regions, plateaux, coasts, islands, etc.).

2.8.3 Each Member shall establish and maintain at least one reference climatological station.

2.8.4 Each Member shall establish and maintain an up-to-date directory of the climatological stations in its territory, giving the standard metadata specified in the Manual on WIGOS (WMO-No. xxx) ~~and~~including at least the following information~~, often referred to as metadata,~~ for each station:
(a) Name and geographical coordinates;
(b) Elevation of station;
(c) A brief description of the local topography;
(d) Category of station and details of observing programmes;
(e) Exposure of instruments, including height above ground of thermometers, raingauges and anemometers;
(f) A station history (date of beginning of records, changes of site, closure or interruption of records, changes in the name of the station and important changes in the observing programme);
(g) The name of the supervising organization or institution;
(h) The datum level to which atmospheric pressure data of the station refer.

2.8.5 The data relating to the elevation of a climatological station should be specified to the nearest metre.

Note:Information on the accurate specification of the geographical coordinates and elevation of a station is provided in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, 1.3.3.2.

Location and composition

2.8.~~5~~6 Each climatological station should be located at a place and under an arrangement that will provide for the continued operation of the station for at least 10 years, and for the exposure to remain unchanged over a long period, unless it serves a special purpose that justifies its functioning for a shorter period.

2.8.~~6~~7 Each reference climatological station should be sited with an adequate and unchanged exposure where the observations can be made in representative conditions. The surroundings of the station should not alter in time to such an extent as to affect the homogeneity of the series of observations.

~~2.8.7 The data relating to the elevation of a climatological station should be specified at least to the nearest five metres, except that for a station with a barometer the elevation should be specified to the nearest metre.~~

2.8.8 At a principal climatological station, observations shall be made of all or most of the following meteorological elements where appropriate:
(a) Weather;
(b) Wind direction and speed;
(c) Cloud amount;
(d) Type of cloud;
(e) Height of cloud base;
(f) Visibility;
(g) Air temperature (including extreme temperatures);
(h) Humidity;
(i) Atmospheric pressure;
(j) Precipitation amount;
(k) Snow cover;
(l) Sunshine duration and/or solar radiation;
(m) Soil temperature.

2.8.9 At a principal climatological station, soil temperature should be measured at some or all of the following depths: 5, 10, 20, 50, 100, 150 and 300 cm.

2.8.10 At an ordinary climatological station, observations shall be made of extreme temperatures and amount of precipitation and, if possible, of some of the other meteorological elements listed in 2.8.8 above.

2.8.11 At an automatic climatological station, records should be made of meteorological elements selected from those in 2.8.8 above.

Frequency and timing of observations

2.8.12 Each Member should arrange that observations at any climatological station are made at fixed hours, according to either UTC or Local Mean Time, which remain unchanged throughout the year.

2.8.13 When two or more observations are made at a climatological station, they should be arranged at times that reflect the significant diurnal variations of the climatic meteorological elements.

2.8.14 When changes are made in a network of the times of climatological observations, simultaneous observations should be carried out at a skeleton network of representative stations for a period covering the major climatic seasons of the area at the old times of observation and at the new ones.

2.9 Global Climate Observing System Surface Network (GSN) stations

In implementing the observing programme at GCOS Surface Network (GSN) stations, Members should adhere ~~as appropriate~~ to the GCOS Climate Monitoring Principles adopted by Resolution 9 (Cg-XIV). In particular, they should comply with the following best practices:

(a) Long-term continuity should be provided for each GSN station: this requires the provision of the necessary resources, including well-trained staff, and keeping changes ~~of~~ in location to a minimum. In the case of significant changes in ~~sensor devices~~ instrumentation or station location, Members should ~~provide~~ manage these changes in such a way as to avoid the introduction of inhomogeneities into the measurement record. That may require operating old and new instruments simultaneously for a sufficiently long period of overlap (at least one but preferably two years) ~~with dual operation of old and new systems~~ to enable systematic biases between old and new measurement systems to be derived~~comparisons to be made and the identification of inhomogeneities and other measurement characteristics~~;

(b) CLIMAT data should be provided in an accurate and timely manner: CLIMAT reports should be transmitted by the fifth day of the month but not later than the eighth day of the month;

(c) Rigorous quality control ~~should be exercised~~ on the measurements and their message encoding should be exercised: CLIMAT reports require quality control of the measurements themselves and their message encoding to ensure their accurate transmission to national, regional and world centres for their use. Quality-control checks should be made on site and at a central location designed to detect equipment faults at the earliest stage possible. The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part III, Chapter 3, provides the appropriate recommendations;

(d) The site layout should follow the ~~recommended form: the layout of the site should follow the~~ recommendations in the *Guide to the Global Observing System* (WMO-No. 488);

(e) The site and instruments should be inspected regularly and maintained according to WMO recommended practices.~~: t~~ To obtain homogeneous datasets, maintenance should be carried out as ~~is~~ documented in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8)~~. The quality of the measured variables should be guaranteed by appropriate inspection of sites, instruments and exposure to be based on the procedures given in the Guide. As part of the maintenance, the necessary calibration practices should be traceable to the standards provided by the Guide~~;

(f) A national plan should be developed to archive daily data from GSN stations for climate and climate research purposes: the archive should include both observations and observational ~~data and~~ metadata pertaining to each climate station as specified in the Manual on WIGOS (WMO-No. xxx)~~. Metadata should include data concerning a station's establishment, subsequent maintenance and changes in exposure, instrumentation and staff. The data and metadata should be in its original form as well as in digital format~~;

(g) Detailed metadata and historical climate data for each GSN station should be provided: a GSN Data Centre should have an up-to-date digital copy of the historical climate data and all types of metadata for GSN stations. A current copy of the long-term series of data and metadata from GSN stations should be made available.

2.10 Global Climate Observing System Upper-air ~~Network (GUAN)~~ stations

2.10.1 Global Climate Observing System Upper-air Network (GUAN) stations

In implementing observing programmes at GCOS Upper-air Network (GUAN) stations, Members should adhere ~~as appropriate~~ to the GCOS Climate Monitoring Principles adopted by Resolution 9 (Cg-XIV). In particular, they should comply with the following best practices:

(a) Long-term continuity should be ~~provided for~~ensured at each GUAN station: this requires the provision of the necessary resources, including well-trained staff, and keeping changes ~~of~~in location to a minimum. Changes

~~of bias caused by changes~~ in instrumentation must be managed in such a way that no systematic bias is introduced into the measurement time series. This may be accomplished by ensuring~~should be evaluated by~~ a sufficient overlapping period of observation (perhaps as much as a year) between the old and new measurement systems or by making use of the results of instrument intercomparisons made at designated test sites;

(b) Soundings should preferably be made at least twice per day and should reach as high as possible, noting the GCOS requirements for ascents up to a minimum height of 30 hPa. Since climate data are needed in the stratosphere to monitor changes in the atmospheric circulation and to study the interaction between stratospheric circulation, composition and chemistry, every effort should be made to maintain soundings regularly up to a level as high as 5 hPa where feasible, noting the above GCOS requirements;

(c) Rigorous quality control should be exercised at each GUAN site: periodic calibration, validation and maintenance of the equipment should be carried out to maintain the quality of the observations;

(d) Basic checks should be made before each sounding to ensure accurate data: the accuracy of a radiosonde's sensors should be checked in a controlled environment immediately before the flight. Checks should also be made during and/or at the end of each sounding to ~~assure~~ ensure that incomplete soundings or soundings containing errors are corrected before transmission;

(e) Back-up radiosondes should be released in cases of failure: in the event of failure of a sounding instrument or incomplete sounding resulting from difficult weather conditions, a second release should be made to maintain the record from the GUAN station;

(f) Detailed metadata for each GUAN station should be provided: the batch identifier on the radiosondes should be logged for each flight, so that faulty batches can be identified and the data amended or eliminated from the climate records, if necessary. Up-to-date records of metadata in a standard format should be provided to the GUAN Data Centre~~ so that shifts in the data will not be mistaken for climate change. The metadata should include detailed information about the station, such as location, elevation, operating instruments and their changes over time. Changes to operating and correction procedures should also be recorded~~. Both the corrected and uncorrected upper-air observation should be archived. Climate change studies require extremely high stability in the systematic errors of the radiosonde measurements~~.~~;

(g) To achieve suitable global coverage, Members should consider operating stations outside of national boundaries.

2.10.2 Global Climate Observing System Reference Upper-Air Network (GRUAN) stations

In implementing observing programmes ~~at~~contributing to the GCOS Reference Upper-Air Network (GRUAN) ~~stations~~, such programmes must undergo the GRUAN site assessment and certification process. ~~Members should adhere to the provisions of 2.10.1 for GUAN stations and also ….. (to be completed) …..~~In particular, GRUAN sites shall comply with the following best practices:

(a) To ensure that GRUAN measurements meet their design criteria and serve the needs of the climate monitoring community, long-term continuity of measurement series should be ensured at each GUAN site: this requires the provision of the necessary resources, including well-trained staff, long-term funding, and support for replacement of aging measurement systems;

(b) Robust change management protocols shall be implemented to ensure the long-term homogeneity of the measurement series at GRUAN sites. Changes to measurement systems shall not be made without advanced notification to the GRUAN Lead Centre;

(c) Sufficient raw and metadata shall be collected at contributing sites to permit the processing of measurements at a centralized processing facility into a reference measurement i.e. that at a minimum, the uncertainty of the measurement (including corrections) has been determined, the entire measurement procedure and set of processing algorithms are properly documented and accessible, and that every effort has been made to tie the observations to an internationally accepted traceable standard. Sufficient metadata must also be collected and archived to allow reprocessing of the data at any future date;

(d) In addition to requiring long-term homogeneity of measurement series at each site within the network, sites shall also be operated in such a way that homogeneity of measurements across the network will ensure that significant site specific differences between GRUAN data and co-located measurements do not result from the GRUAN data products;

(e) GRUAN sites shall perform regular traceable pre-launch ground checks for balloon-borne systems and record the results. Other instruments which provide vertical profiles extending from the surface require regular checks to assure correct operation;

(f) GRUAN sites shall provide redundant reference observations of the ECVs selected for measurement at the site at intervals sufficient to validate the derivation of the uncertainty in the primary measurement;

(g) To achieve suitable global coverage, Members should consider operating stations outside of national boundaries.

Note:The mandatory practices required of GRUAN sites, as detailed in the GRUAN Manual (GCOS-170, WIGOS Technical Report No. 2013-02), reflect GRUAN's primary goal of providing reference quality observations of the atmospheric column while accommodating the diverse capabilities of sites within the network. However, certification of measurement programmes at a GRUAN site goes beyond considering the extent to which the site adheres to the mandatory practices outlined in the GRUAN Manual and considers the added value that the site brings to the network. The assessment of the added value is an expert judgement by the Working Group on GRUAN under the considerations 8.17 to 8.26 in the GRUAN Manual. The GRUAN Manual is augmented by a more detailed GRUAN Guide to Operations (GCOS-171, WIGOS Technical Report

No. 2013-03) which provides guidelines on how the protocols detailed in GRUAN Manual might be achieved, and by a series of technical documents available from the GRUAN web site at http://www.gruan.org.

2.11 Agricultural meteorological stations

General

2.11.1 Each Member should establish in its territory a network of agricultural meteorological stations.

2.11.2 The desirable density of the network of each category of agricultural meteorological stations should be adequate to delineate weather parameters on the scale required for agrometeorological planning and operation, taking into account the agricultural features of the country.

2.11.3 Each Member should maintain an up-to-date directory of the agricultural meteorological stations in its territory, giving the standard metadata specified in the Manual on WIGOS (WMO-No. xxx) ~~and~~including at least the following information~~, often referred to as metadata,~~ for each station:

(a) Name and geographical coordinates;
(b) Elevation of station;
(c) A brief description of the local topography;
(d) Natural biomass, main agrosystems and crops of the area;
(e) Types of soil, physical constants and profile of soil;
(f) Category of station, details of observing programme and reporting schedule;
(g) Exposure of instruments, including height above ground of thermometers, raingauges and anemometers;
(h) A station history (date of beginning of records, changes of site, closure or interruption of records, changes in the name of the station and important changes in the observing programme);
(i) The name of the supervising organization or institution.

Location and composition

2.11.4 Each agricultural meteorological station should be located at a place that is representative of agricultural and natural conditions in the area concerned, preferably:

(a) At experimental stations or research institutes for agriculture, horticulture, animal husbandry, forestry, hydrobiology and soil sciences;
(b) At agricultural and allied colleges;
(c) In areas of present or future importance for agricultural and animal husbandry;
(d) In forest areas;
(e) In national parks and reserves.

2.11.5 At an agricultural meteorological station, the observing programme should, in addition to the standard climatological observations, include some or all of the following:

(a) Observations of physical environment:
    (i) Temperature and humidity of the air at different levels in the layer adjacent to the ground (from ground level up to about 10 metres above the upper limit of prevailing vegetation), including extreme values of these meteorological elements;
    (ii) Soil temperature at depths of 5, 10, 20, 50 and 100 cm and at additional depths for special purposes and in forest areas;
    (iii) Soil water (volumetric content) at various depths, with at least three replications when the gravimetric method is used;
    (iv) Turbulence and mixing of air in the lower layer (including wind measurements at different levels);
    (v) Hydrometeors and water-balance components (including hail, dew, fog, evaporation from soil and from open water, transpiration from crops or plants, rainfall interception, runoff and water table);
    (vi) Sunshine, global and net radiation as well as the radiation balance over natural vegetation, and crops and soils (over 24 hours);
    (vii) Observations of weather conditions producing direct damage to crops, such as frost, hail, drought, floods, gales and extremely hot dry winds;
    (viii) Observations of damage caused by sandstorms and duststorms, atmospheric pollution and acid deposition as well as forest, bush and grassland fires.
(b) Observations of a biological nature:
    (i) Phenological observations;
    (ii) Observations on growth (as required for the establishment of bioclimatic relationships);
    (iii) Observations on qualitative and quantitative yield of plant and animal products;
    (iv) Observations of direct weather damage on crops and animals (adverse effects of frost, hail, drought, floods, gales);
    (v) Observations of damage caused by diseases and pests;
    (vi) Observations of damage caused by sandstorms and duststorms and atmospheric pollution, as well as forest, bush and grassland fires.

Frequency and timing of observations

2.11.6 Observations of a physical nature should be made at the main synoptic times. Observations of a biological nature should be made regularly or as frequently as significant changes occur and should be accompanied by meteorological observations.

2.12 Special stations

2.12.1 General

2.12.1.1 In addition to the stations discussed previously, Members should establish special stations.

Note:In some cases, these special stations are collocated with surface or upper-air stations of the RBSNs.

2.12.1.2 Members should cooperate in the establishment of special stations for particular purposes.

2.12.1.3 Special stations shall include:
(a) Weather radar stations;
(b) Radiation stations;
(c) Wind profiler stations;
(d) Atmospherics detection stations;
(e) Meteorological reconnaissance aircraft stations;
(f) Meteorological rocket stations;
(g) Global Atmosphere Watch (GAW) stations;
(h) Planetary boundary-layer stations;
(i) Tide-gauge stations.

2.12.1.4 A special station should be identified by its name and geographical coordinates, and elevation.

2.12.2 Weather radar stations

General

2.12.2.1 Members should establish an adequate network of weather radar stations, either nationally or in combination with other Members of the Region or Regions, in order to secure information about areas of precipitation and associated phenomena and about the vertical structure of cloud systems, for ~~both~~ operational meteorology, hydrology, climatology and research.

Location and composition

2.12.2.2 Weather radars shall be located in such a manner as to minimize interference from surrounding hills, buildings and electro-magnetic sources, so as to provide good coverage of population centres and geographic features affecting stream and river flows, major thoroughfares and other facilities of importance.

Frequency and timing of observations

2.12.2.3 As a minimum, observations should be taken and reported at hourly intervals. Observations should be more frequent when heavy convective activity or heavy widespread precipitation is occurring.

2.12.3 Radiation stations

General

2.12.3.1 Members should establish at least one principal radiation station in each climatic zone of their territory.

2.12.3.2 Members should maintain a network of radiation stations of sufficient density for the study of radiation climatology.

2.12.3.3 Each Member should maintain an up-to-date directory of the radiation stations in its territory, including ordinary and principal stations, giving the following information for each station:
(a) Name and geographical coordinates in degrees and minutes of arc;
(b) Elevation of station in whole metres;
(c) A brief description of local topography;
(d) Category of station and details of the observing programme;
(e) Details of radiometers in use (type and serial number of each instrument, calibration factors, dates of any significant changes);
(f) Exposure of radiometers, including height above ground, details of the horizon of each instrument and nature of the surface of the ground;
(g) A station history (date of beginning of records, changes of site, closure or interruption of records, changes in the name of the station and important changes in the observing programme);
(h) Name of the supervising organization or institution.

Location and composition

2.12.3.4 Each radiation station shall be sited, as far as possible, with an adequate exposure, where the observations can be made in representative conditions.

Note: The exposure and surroundings of the stations should not alter in time to such an extent as to affect the homogeneity of the series of observations.

2.12.3.5 At principal radiation stations, the observing programme should include:
(a) Continuous recording of global solar radiation and sky radiation, using pyranometers of the first or second class;
(b) Regular measurements of direct solar radiation;
(c) Regular measurements of net radiation (radiation balance) over natural and crop soil cover (throughout 24 hours);
(d) Recording of duration of sunshine.

Note: The terminology of radiation qualities and measuring instruments and the classification of pyranometers is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 7.

2.12.3.6 At ordinary radiation stations, the observing programme should include:
(a) Continuous recording of global solar radiation;
(b) Recording of duration of sunshine.

2.12.3.7 Pyrheliometric measurements shall be expressed in accordance with the World Radiometric Reference (WRR).

Frequency and timing of observations

2.12.3.8 When automatic recording is not available, measurements of direct solar radiation should be made at least three times a day, provided the sun and the sky in the vicinity are free from cloud, corresponding to three different solar heights, one of them being near the maximum.

2.12.3.9 During clear-sky conditions, measurements of long-wave effective radiation should be made every night, one of them being made soon after the end of the evening civil twilight.

2.12.4 Wind profiler stations

General

2.12.4.1 Members should consider the establishment of wind profilers.

Location

2.12.4.2 Wind profiler stations should be located so as to measure wind profiles in the troposphere. The spacing of stations should be consistent with the requirements for the observations.

2.12.5 Atmospherics detection stations

General

2.12.5.1 Members should establish atmospherics detection stations.

Note: Methods in use are described in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part II, Chapter 7.

Location and composition

2.12.5.2 Atmospherics (spherics) detection stations should be located so as to measure this phenomenon in areas of frequent convective activity. The spacing and number of ground stations should be in keeping with the technique used, coverage and accuracy of location desired.

Frequency and timing of observations

2.12.5.3 Continuous monitoring by the station should be maintained, with an indication of direction and distance, at about 10-minute intervals.

2.12.6 Meteorological reconnaissance aircraft stations

General

2.12.6.1 Members are encouraged to organize and communicate, either individually or jointly, routine and special aircraft weather reconnaissance flights.

Location and composition

2.12.6.2 Aircraft reconnaissance facilities should be located near prevalent storm tracks in data-sparse areas. Reconnaissance flights should be initiated in locations where additional observational information is required for the investigation and prediction of developing or threatening storms.

2.12.6.3 Meteorological reconnaissance flight observations should include:
(a) Altitude and position of aircraft;
(b) Observations made at frequent intervals during a horizontal flight at low level;
(c) Observations made during flights at higher levels, as near as possible to standard isobaric surfaces;
(d) Vertical soundings, either by aircraft or by dropsonde.

2.12.6.4 The meteorological elements to be observed during meteorological reconnaissance flights should include:
(a) Atmospheric pressure at which the aircraft is flying;
(b) Air temperature;
(c) Humidity;
(d) Wind (type of wind, wind direction and speed);
(e) Present and past weather;
(f) Turbulence;
(g) Flight conditions (cloud amount);
(h) Significant weather changes;
(i) Icing and contrails.

Notes:
1. For detailed guidance regarding observations made during meteorological reconnaissance flights, see the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8).
2. Type of wind refers to how the wind was determined and whether it was a mean or a spot wind.

Frequency and timing of observations

2.12.6.5 Reconnaissance flights should be scheduled in response to requirements for data from data-sparse areas, or in response to special phenomena.

2.12.6.6 Flight times and frequency should be selected so that reconnaissance information supplements upper-air information.

2.12.7 Meteorological rocket stations

General

2.12.7.1 Members are encouraged to establish meteorological rocket stations.

Note:When establishing and operating these stations, appropriate safety precautions are considered necessary and need to be coordinated with the relevant air traffic control authorities.

Location and composition

2.12.7.2 Members establishing rocket stations should coordinate their locations through WMO so that continuous networks can be maintained. Meteorological elements to be measured include:
(a) Wind direction and speed;
(b) Air temperature;
(c) Solar radiation;
(d) Electrical variables;
(e) Minor chemical constituents.

Frequency and timing of observations

2.12.7.3 The frequency and timing of launches should be coordinated, because of cost, among Members concerned to allow simultaneous sampling at rocket network stations. Information on launches should be communicated to the WMO Secretariat.

2.12.8 Global Atmosphere Watch (GAW) stations

Note: Technical regulations relating to the observing component of the Global Atmosphere Watch (GAW) are contained in the *Technical Regulations* (WMO-No. 49) Volume I General Standards and Recommended Practices, Part I WMO Integrated Global Observing System (WIGOS), and in the Manual on WIGOS (WMO-No. xxx). Further information on GAW stations is contained in the GAW Station Information System (GAWSIS) at http://gaw.empa.ch/gawsis/ as well as the appropriate Global Atmosphere Watch technical publications, and the *Guide to the Global Observing System* (WMO-No. 488).

~~General~~

~~2.12.8.1 Members should cooperate in the establishment of a minimum of 30 global GAW stations and at least 300~~

~~regional GAW stations.~~

~~Location and composition~~

~~2.12.8.2 Global Atmosphere Watch stations should be established only at sites where direct pollution effects can be avoided.~~

~~2.12.8.3 Global Atmosphere Watch stations should be collocated with or located near a surface and/or an upper-air synoptic station.~~

~~Note:For further information on the location of GAW stations, see the Technical Regulations (WMO-No. 49), Volume I – General Meteorological Standards and Recommended Practices, Part II, 2.4.3, Note 3, as well as the appropriate Global Atmosphere Watch technical publications and the Guide to the Global Observing System (WMO-No. 488).~~

~~2.12.8.4 At each global GAW station, measurements should be carried out on all or most of the following variables:~~
~~(a) Greenhouse gases (concentration near the surface, total column density and vertical profile): carbon dioxide; chlorofluorocarbons, their substitutes, intermediates and final products; methane; nitrous oxide; tropospheric ozone;~~
~~(b) Ozone (concentration near the surface, total column density and vertical profile) and related precursor gases, e.g. volatile organic compounds ((VOCs) NOx);~~
~~(c) Radiation and the optical depth or transparency of the atmosphere: turbidity, solar radiation, ultraviolet B radiation, visibility, total aerosol load (concentration near the surface, in a marine or continental background and, where possible, vertical profile up to the tropopause);~~
~~(d) Chemical composition of precipitation;~~
~~(e) Reactive gas species (concentration near the surface, total column density and vertical profile): sulphur dioxide, reduced sulphur species, oxides of nitrogen, reduced nitrogen species, carbon monoxide, VOCs, peroxyacetyl nitrate (PAN), hydrogen peroxide (H2O2) and others;~~
~~(f) Physical and chemical characteristics of atmospheric particles, including mineral aerosols and their vertical distribution;~~
~~(g) Radionuclides, krypton-85, radon, tritium, isotopes of selected substances;~~
~~(h) Routine measurements of the classical meteorological elements (in particular wind direction and speed, wet- and dry-bulb air temperature, relative humidity, atmospheric pressure, present weather, aerological soundings);~~
~~(i) Chemical composition of water in the soil and plants, in collaboration with other interested organizations;~~
~~(j) Integrated air samples for archiving.~~

~~2.12.8.5 At regional GAW stations, measurements should be made of as many of the variables listed in 2.12.8.4 (a) to (j) above as possible and others as the needs of the region or country dictate. However, the following variables should constitute the core measurement programme at GAW regional stations, with the highest priority given to the first five:~~
~~(a) Ozone concentration near the surface;~~
~~(b) Precipitation chemistry;~~
~~(c) Carbon black (in precipitation and in aerosols);~~
~~(d) Meteorological parameters;~~
~~(e) Solar radiation (visible, ultraviolet B);~~
~~(f) Methane;~~
~~(g) Carbon monoxide;~~
~~(h) Total ozone;~~
~~(i) Aerosol composition.~~

~~Frequency and timing of observations~~

~~2.12.8.6 At GAW stations, observations of most parameters should be continuous with reports prepared on an hourly basis.~~

2.12.9 Planetary boundary-layer stations

General

2.12.9.1 Members should establish an adequate net-work of stations for making measurements in the planetary boundary layer.

Location and composition

2.12.9.2 Members should, whenever possible, provide a capability to obtain detailed knowledge of the profiles of temperature, humidity, pressure and wind in the lowest 1 500 m of the atmosphere.

Notes:
1. This information is required in the study of diffusion of atmospheric pollution, the transmission of electromagnetic signals, the relation between free-air variables and boundary-layer variables, severe storms, cloud physics, convective dynamics, etc.

2. The accuracy of measurements of several variables and the height intervals at which they are required depend upon the nature of the problems under study.
3. Some of the vertical and horizontal sounding systems which could be applied to specific problems for limited periods in a variety of locations are described in the *Guide to the Global Observing System* (WMO-No. 488).

2.12.10 Tide-gauge stations

General

2.12.10.1 Members should establish an adequate network of tide-gauge stations along coasts subject to storm surges.

Location and composition

2.12.10.2 Gauges should be placed in a manner that allows determination of the full range of water heights.

Frequency and timing of observations

2.12.10.3 Observations of tide height should be made at the main synoptic times, 0000, 0600, 1200 and 1800 UTC. In coastal storm situations, hourly observations should be made.

3. EQUIPMENT AND METHODS OF OBSERVATION

Note:The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) is the authoritative reference for all matters related to methods of observations. It should be consulted for more detailed descriptions.

3.1 General requirements of a meteorological station

3.1.1 All stations shall be equipped with properly calibrated instruments and adequate observational and measuring techniques, so that the measurements and observations of the various meteorological elements are accurate enough to meet the needs of synoptic meteorology, aeronautical meteorology, climatology and of other meteorological disciplines.

Note:For detailed guidance on instruments and methods of observation, see the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) and *Weather Reporting* (WMO-No. 9), Volume D – Information for Shipping.

3.1.2 To satisfy data requirements, primary data from surface-based instruments and observing systems shall be converted into meteorological variables.

3.1.3 The exposure of instruments for the same type of observation at different stations shall be similar in order that observations may be compatible.

3.1.4 A reference height shall be established at each meteorological station.

3.1.5 In order to ensure maintenance of a high standard of observations and the correct functioning of instruments, stations shall be inspected periodically.

3.1.6 Station inspections should be carried out by experienced personnel and should ensure that:
(a) The siting and exposure of instruments are known, recorded and acceptable;
(b) Instruments have approved characteristics, are in good order and regularly verified against relevant standards;
(c) There is uniformity in the methods of observation and in the procedure for reduction of observations;
(d) The observers are competent to carry out their duties.

3.1.7 All synoptic land stations should be inspected ~~not less than~~ at least once every two years.

3.1.8 Agricultural meteorological and special stations should be inspected at least once every year.

3.1.9 Principal climatological stations should be inspected at least once every year; ordinary climatological and precipitation stations should be inspected at least once every three years. If possible, relevant inspections should occasionally be carried out during the winter season.

3.1.10 Automatic weather stations should be inspected not less than once every six months.

3.1.11 At sea stations, barometers should be checked at least twice a year with reference to a standard barometer.

3.2 General requirements of instruments

3.2.1 Meteorological instruments should be reliable and accurate.

3.2.2 Instruments in operational use shall be periodically compared directly or indirectly with the relevant national standards.

3.2.3 Where automated instrument systems are employed, reference (or check) values of variables shall also be measured taking into consideration criteria for the allowed difference between the reference and compared instruments as well as the appropriate minimum time interval between comparisons.

3.2.4 At reference climatological stations, any change in instrumentation should be such as not to decrease the degree of accuracy of any observations as compared with the earlier observations, and any such change should be preceded by an adequate overlap (at least two years) with the earlier instrumentation.

3.2.5 Unless otherwise specified, instruments designated as regional and national standards should be compared by means of travelling standards at least once every five years.

3.2.6 In order to control effectively the standardization of meteorological instruments on a national and international scale, a system of national and regional standards, as adopted by the World Meteorological Organization, shall be applied in the GOS. (See *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1.)

3.3 Surface observations

3.3.1 General

3.3.1.1 An observation should be made in such a way that:
(a) A representative temporally smoothed value of the variable can be found in the vicinity of the station;
(b) All representative extreme values (or other indicator of dispersion) can be determined, if required;
(c) All synoptic-scale discontinuities (e.g. fronts) can be identified as soon as possible after the observation is made.

3.3.1.2 To satisfy these requirements, observational methods should be selected so as to achieve:
(a) Suitable temporal and/or spatial samples of each variable;
(b) A justifiable accuracy for the measurement of each variable;
(c) A representative observation height above the ground.

3.3.1.3 To avoid the effect of small-scale fluctuations, the meteorological variable should be sampled continuously or repeatedly over a suitable time for the purpose of observing representative mean and extreme values. Alternatively, instruments with a suitable lag or damping effect should be used to eliminate or substantially reduce high-frequency noise.

3.3.1.4 The averaging time should be short compared with the temporal scale of such discontinuities as fronts or squall lines, which usually delineate air masses of different characteristics whilst removing the effects of small-scale disturbance. For example, for synoptic purposes an average taken over 1 to 10 minutes will suffice for the measurement of atmospheric pressure, air temperature, humidity, wind, sea surface temperature and visibility.

3.3.1.5 Instrumental readings shall be corrected and reduced as appropriate.

3.3.2 Atmospheric pressure

3.3.2.1 Barometric readings shall be reduced from local acceleration of gravity to standard (normal) gravity. The value of standard (normal) gravity (symbol g_n) shall be regarded as a conventional constant.

$$g_n = 9.806\ 65 \text{ m/s}$$

3.3.2.2 The hectopascal (hPa), equal to 100 pascals (Pa), shall be the unit in which pressures are reported for meteorological purposes.

Note:One hectopascal (hPa) is physically equivalent to one millibar (mb) and thus no changes are required to scales or graduations made in millibars in order to read them in hectopascals.

3.3.2.3 Atmospheric pressure shall be determined by a suitable pressure measuring device of uncertainty specified in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, Annex 1.D~~B~~.

3.3.2.4 In order for mercury barometer readings made at different times and at different places to be comparable, the following corrections should be made:
(a) Correction for index error;
(b) Correction for gravity;
(c) Correction for temperature.

3.3.2.5 Whenever it is necessary to compute the theoretical local value of the acceleration due to gravity, each Member shall follow the procedure given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 3, Annex 3.A.

3.3.2.6 Atmospheric pressure at a station shall be reduced to mean sea level, except at those stations where regional association resolutions prescribe otherwise.

3.3.2.7 The results of comparisons of national and regional reference standard barometers shall be reported to the Secretariat for communication to all Members concerned.

3.3.2.8 Regional comparisons of national standard barometers with a regional standard barometer shall be arranged at least once every 10 years.

3.3.2.9 Reference standards for comparison purposes may be provided by a suitable pressure measuring device that, generally, shall be of the highest metrological quality available at a given location or in a given organization from which measurements made there are derived.

3.3.2.10 In calibration against a standard barometer whose index errors are known and allowed for, tolerances for a station barometer stated in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 3 should not be exceeded.

3.3.3 Air temperature

3.3.3.1 One of the following three main types of thermometer shall be used:
(a) Liquid-in-glass thermometer;
(b) Resistance thermometer;
(c) Thermocouples.

All temperature shall be reported in degrees Celsius.

3.3.3.2 An instrument height of between 1.25 and 2.0 m above ground is considered satisfactory to obtain representative air temperature measurements. However, at a station where considerable snow cover may occur, a greater height is permissible or, alternatively, a moveable support can be used allowing the thermometer housing to be raised or lowered in order to keep the correct height above the snow surface.

3.3.3.3 Thermometer screens should be constructed so as to minimize radiation effects and at the same time allow free influx and circulation of air.

3.3.3.4 Thermometers should be checked against a reference standard instrument every two years.

Note: The required uncertainties are given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, Annex 1.D~~B~~.

3.3.3.5 For psychrometric purposes, thermometers shall be read to at least 0.1°C.

3.3.4 Humidity

Note: Definitions and specifications of water vapour in the atmosphere are given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 4, Annex 4.A.

3.3.4.1 In surface observations, at temperatures above 0°C values of humidity should be derived from the readings of a psychrometer or other instrument of equal or better accuracy.

3.3.4.2 If forced ventilation of psychrometers is used the airflow past the thermometer bulbs should be between 2.5 m/s and 10 m/s.

3.3.4.3 In surface observations the height requirements for humidity measurements shall be the same as for air temperature measurements.

3.3.5 Surface wind

3.3.5.1 The exposure of wind instruments over level, open terrain shall be 10 metres above the ground.

Note: Open terrain is defined as an area where the distance between the anemometer and any obstruction is at least 10 times but preferably 20 times the height of the obstruction.

3.3.5.2 At aeronautical stations the wind sensors should be exposed to provide measurements representative of conditions 6 to 10 metres above the runway at the average take-off and touch-down areas.

3.3.5.3 Wind speed should be measured to the nearest unit (metres per second, kilometres per hour or knots), and should represent, for synoptic reports, an average over 10 minutes or, if the wind changes significantly in the 10-minute period, an average over the period after the change.

Note:In observations used at an aerodrome for aircraft taking off and landing, the averaging period is two minutes and the speed is reported in metres per second, kilometres per hour or knots with an indication of the unit used.

3.3.5.4 Wind direction should be measured in degrees and reported to the nearest 10 degrees and should represent a scalar average over 10 minutes or, if the wind changes significantly in the 10-minute period, an average over the period after the change.

3.3.5.5 "Calm" should be indicated when the average wind speed is less than 0.5 m/s. The direction in this case is not measured for synoptic purposes.

3.3.5.6 In the absence of an anemometer, the wind speed may be estimated using the Beaufort scale.

Note:The Beaufort scale is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 5.

3.3.5.7 At sea stations, in the absence of appropriate instrument, the wind speed may be estimated by reference to the Beaufort scale and the wind direction by observing the motion of sea waves.

3.3.6 Clouds

3.3.6.1 For all cloud observations, the tables of classification, definitions and descriptions of general species and varieties of clouds as given in the International Cloud Atlas (WMO-No. 407), Volume I – Manual on the Observation of Clouds and other Meteors – (Annex I to the WMO Technical Regulations), shall be used.

3.3.6.2 Height of cloud base should preferably be determined by measurement.

3.3.7 Weather

See *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 14, paragraph 14.2.

3.3.8 Precipitation

3.3.8.1 The amount of precipitation shall be the sum of the amounts of liquid precipitation and the liquid equivalent of solid precipitation.

3.3.8.2 Daily amounts of precipitation should be measured to the nearest 0.2 mm and, if feasible, to the nearest 0.1 mm. Daily measurements of precipitation should be made at fixed times.

3.3.8.3 The design and exposure of a raingauge should be such as to minimize the effects of wind, evaporation and splashing, these being the most frequent sources of error.

Note:In general, objects should not be closer to the gauge than a distance twice their height above the gauge orifice.

3.3.9 Sea surface temperature

The method used at manned sea stations for measuring sea surface temperature shall be entered in the relevant meteorological logbook.

3.3.10 Waves

When separate wave systems are clearly distinguish-able, each of them should be recorded.

3.3.11 Radiation

The comparison of radiation instruments on a regional or a global level should be performed at least once every five years. The calibration of radiation instruments should be checked and recalibrated, if necessary, at least once a year against existing standards.

Note:For details of calibration of other radiation sensors, refer to the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 7.

3.3.12 Soil temperature

3.3.12.1 Measurements should be made to detect diurnal variations of soil temperature at depths of 5, 10, 20 and, in some cases, 50 cm.

3.3.12.2 Soil surface temperature measurements are recommended for special purposes.

3.3.13 Soil moisture

3.3.13.1 Gravimetric estimation of soil moisture should be taken as the average of at least three samples from each depth.

3.3.13.2 Gravimetric water content should be expressed as the grams of soil moisture contained in a gram of dry soil.

3.3.14 Evapotranspiration

Observations of evapotranspiration should be representative of the plant cover and moisture conditions of the general surroundings of the station. Separate statements of evapotranspiration from irrigated areas should be provided.

3.3.15 Evaporation

3.3.15.1 Evaporation should be measured by means of evaporation tanks. The design and exposure of the evaporation tanks should ensure the required comparability of observations.

3.3.15.2 Water temperature and wind run records should be taken at each observation.

3.3.15.3 The amount of evaporation should be read in millimetres.

3.3.16 Sunshine duration

The threshold value for bright sunshine should be 120 W/m^2 of direct solar irradiance.

3.4 UPPER-AIR OBSERVATIONS

3.4.1 At an upper-air synoptic station, atmospheric pressure, temperature and humidity (PTU) observations shall be made by means of a radiosonde attached to a fast-ascending free balloon.

Note:For detailed guidance on the radiosonde and balloon techniques, see the *Guide to Meteorological Instrumen*ts *and Methods of Observation* (WMO-No. 8), Part I, Chapters 12 and 13.

3.4.2 Computations of upper-air observations shall be based on the relevant definitions of physical functions and values of constants given in the *Technical Regulations* (WMO-No. 49), Volume I – General Meteorological Standards and Recommended Practices, Appendix A.

3.4.3 At an upper-air synoptic station, upper-wind observations should be made by tracking of the fast-ascending free balloon by electronic means (e.g. radio theodolite, radar or NAVAID).

Note:At stations where the skies are generally clear, upper winds may be determined by optical tracking of a balloon.

3.4.4 Each upper-air station should have an appropriate manual of instructions.

3.4.5 Each upper-air synoptic station shall promptly report on any changes of the types of radiosonde and windfinding systems in operational use to the Secretariat for communication to all Members at least on a quarterly basis.

3.4.6 International comparisons of widely used radiosonde types shall be made at least once every four years.

3.4.7 New radiosonde types should be compared with sondes accepted as having the most stable and accurate performance before adoption for operational use.

3.4.8 At a meteorological reconnaissance aircraft station, electronic means (NAVAID) should be used when a vertical profile of upper winds is to be determined by means of a dropsonde.

ATTACHMENT III.1

STANDARD SET OF METADATA ELEMENTS FOR AUTOMATIC WEATHER STATION INSTALLATIONS

Note: the Manual on WIGOS (WMO-No. xxx) specifies a standard set of metadata for all WIGOS observations. This attachment provides further guidance relevant to Automatic Weather Stations.

A metadata database should provide detailed information necessary for users to gain adequate background knowledge about the station and observational data, together with updates due to changes that occur.

Major database elements include the following:

(a) Network information;
(b) Station information;
(c) Individual instrument information;
(d) Data-processing information;
(e) Data handling information;
(f) Data transmission information.

Station information

There is a great deal of information related to a station's location, local topography, etc. Basic station metadata include:

(a) Station name and station index number(s);
(b) Geographical coordinates;
(c) Elevation above mean sea level;
(d) Types of soil, physical constants and profile of soil;
(e) Types of vegetation and condition;
(f) Local topography description;
(g) Type of automatic weather station (AWS), manufacturer, model, serial number;
(h) Observing programme of the station: parameters measured, reference time, times at which observations/measurements are made and reported;
(i) The datum level to which atmospheric pressure data of the station refer.

Individual instrument information

(Information related to sensors installed at the station, including recommended, scheduled and performed maintenance and calibration)

Relevant metadata should be:

(a) Sensor type, manufacturer, model, serial number;
(b) Principle of operation; method of measurement/observation; type of detection system;
(c) Performance characteristics;
(d) Unit of measurement, measuring range;
(e) Resolution, accuracy (uncertainty), time constant, time resolution, output averaging time;
(f) Siting and exposure: location, shielding, height above ground (or level of depth);
(g) Data acquisition: sampling interval, averaging interval and type;
(h) Correction procedures;
(i) Calibration data and time of calibration;
(j) Preventive and corrective maintenance: recommended/scheduled maintenance and calibration procedures, including frequency, procedure description;
(k) Results of comparison with travelling standard.

Data-processing information

For each individual meteorological element, metadata related to processing procedures include:

(a) Measuring/observing programme: time of observations, reporting frequency, data output;
(b) Data-processing method/procedure/algorithm;
(c) Formula to calculate the element;
(d) Mode of observation/measurement;
(e) Processing interval;
(f) Reported resolution;
(g) Input source (instrument, element, etc.);
(h) Constants and parameter values.

Data handling information

Metadata elements of interest include:

(a) Quality control procedures/algorithms;
(b) Quality control flags definition;
(c) Constants and parameter values;
(d) Processing and storage procedures.

Data transmission information

The transmission-related metadata of interest are:

(a) Method of transmission;
(b) Data format;
(c) Transmission time;
(d) Transmission frequency.

PART IV

SPACE-BASED SUBSYSTEM

Note: regulatory material applicable to the space-based sub-system of the GOS is contained in the Manual on WIGOS (WMO-No. xxx)

~~1. COMPOSITION OF THE SUBSYSTEM~~

~~The main elements of the space-based subsystem are:~~
~~(a) An Earth observation space segment:~~
~~(i) Operational satellites on Geostationary Earth Orbit (GEO);~~
~~(ii) Operational satellites on distributed, sun-synchronous, Low Earth Orbits (LEO);~~
~~(iii) Other operational/sustained satellites or instruments on appropriate orbits;~~
~~(iv) Research and development (R&D) satellites;~~
~~(b) A space-based intercalibration system;~~
~~(c) Associated ground segment for data reception, dissemination and stewardship;~~
~~(d) A user segment.~~

~~Notes:~~
~~1. Information on the detailed characteristics and capabilities of current and planned systems of environmental satellites of the GOS is contained in the database on Observing Systems Capability Analysis and Review Tool (OSCAR), which is available online at http://www.wmo.int/oscar.~~
~~2. Information on the principles of remote sensing from space and on the derivation of geophysical variables from space based measurements will be included in the Guide to Meteorological Instruments and Methods of Observations (WMO No. 8), Part IV.~~

~~2. IMPLEMENTATION OF THE SUBSYSTEM~~

~~2.1 General~~

~~2.1.1 Requirements: Operators of environmental satellites should meet, to the extent possible, the uncertainty, timeliness, temporal resolution, spatial resolution and coverage requirements of the GOS as defined in the Rolling Review of Requirements (RRR) process described in Part II of this Manual, and recorded in the requirements database: http://www.wmo.int/oscar.~~

~~2.1.2 Technical coordination: Members operating satellites should ensure the greatest possible compatibility between their different systems, through following recommended Coordination Group for Meteorological Satellites (CGMS) practices, and publish details of the technical characteristics of their instrumentation, data processing and transmissions, as well as the dissemination schedules.~~

~~2.1.3 Continuity: A period of overlap of new and old satellite systems should be ensured to determine inter-satellite biases and maintain the homogeneity and consistency of time series observations, unless reliable transfer standards are available.~~

~~2.1.4 Contingency arrangements: The satellite operators, working together under the auspices of the CGMS or otherwise, should ensure the continuity of operation, and the data dissemination and distribution services of the operational satellites within the subsystem.~~

~~2.1.5 Data collection platforms:~~
~~(a) Members operating satellites with a capability to receive data from data collection platforms (DCP) should maintain technical and operational coordination under the auspices of CGMS in order to ensure compatibility;~~
~~(b) A number of "international" DCP channels should be identical on all geostationary satellites to allow movement of mobile platforms across their individual footprints;~~
~~(c) The satellite operators should publish details of the technical characteristics and operational procedures of their data-collection missions, including the admission and certification procedures.~~

~~2.2 Operational satellites on Geostationary Earth Orbit~~

~~2.2.1 The following capability should be provided:~~
~~(a) Multispectral visible and infrared imagery;~~
~~(b) Infrared sounding;~~
~~(c) Lightning mapping;~~
~~(d) Data collection from in situ observing systems;~~
~~(e) Space environment monitoring;~~
~~(f) Other capabilities as appropriate, for example, broadband and spectral visible and infrared (for Earth radiation budget estimates), high-spectral resolution UV sounding (for atmospheric composition), high-spectral resolution visible and infrared imaging (for ocean colour), solar activity monitoring.~~

~~2.2.2 The constellation of satellites in geostationary orbit should provide full disc imagery at least every 15 minutes, throughout a field of view between 60°S and 60°N. This implies the availability of at least six operational geostationary satellites located at evenly distributed longitudes, with in-orbit redundancy. On-demand rapid-scan capabilities should be implemented where feasible.~~

~~2.2.3 For the imagery mission the availability rate of rectified and calibrated data should be at least 99 per cent as a target. Contingency plans, involving the use of in-orbit standby flight models and rapid call-up of replacement systems and launches, should be in place in order to achieve continuity.~~

~~2.3 Operational spacecraft on distributed sun-synchronous Low Earth Orbits~~

~~2.3.1 The following capability should be provided on several, distributed orbital planes:~~
~~(a) Multispectral visible and infrared imagery;~~
~~(b) Infrared sounding;~~
~~(c) Microwave imagery;~~
~~(d) Microwave sounding;~~
~~(e) Scatterometry (for ocean surface winds);~~
~~(f) Radar altimetry (for ocean surface topography);~~
~~(g) Radio-occultation sounding;~~
~~(h) Broadband visible and infrared radiometry for Earth radiation budget measurements;~~
~~(i) Passive UV sounding (for atmospheric composition monitoring);~~
~~(j) Space environment monitoring including particle detection and magnetic field measurement;~~
~~(k) Solar activity monitoring;~~
~~(l) Data collection from in situ observing systems;~~
~~(m) Direct broadcast;~~
~~(n) Other capabilities as appropriate.~~

~~2.3.2 The orbital configuration of satellites in sun-synchronous orbits should enable the provision of global coverage for visible, infrared and microwave imagery and infrared and microwave sounding, which represents the core meteorological mission, at least six times per day with a regular temporal sampling. This will require sun-synchronous satellites operated along three orbital planes: one ante-meridian (a.m.) orbit with a descending equatorial crossing around 9:30 Local Solar Time (LST), one post-meridian (p.m.) orbit with an ascending equatorial crossing around 13:30 LST, and one early-morning orbit with an ascending equatorial crossing around 17:30 LST. There should be at least one operational satellite on each of these planes, with redundancy on the a.m. and p.m. orbits.~~

~~2.3.3 At least two of these satellites, one in a.m. and one in p.m., should perform infrared sounding with a hyperspectral sensor.~~

~~2.3.4 At least two satellites, one in a.m. and one in p.m, should be equipped with radio-occultation receivers.~~

~~2.3.5 At least two satellites, on well-separated orbits, should be equipped with wind scatterometers.~~

~~2.3.6 At least two satellites, one in a.m. and one in p.m., should perform broadband visible/infrared Earth radiation monitoring.~~

~~2.3.7 At least two sun-synchronous satellites, on well-separated orbits, should be equipped with altimeter packages for global ocean surface topography monitoring.~~

~~2.3.8 Data from these satellites should be acquired on a global basis, without temporal gaps for blind orbits, and delivered to users to meet timeliness requirements.~~

~~2.3.9 The constellation should be designed to achieve a high level of robustness allowing the delivery of imagery and sounding data from at least three polar-orbiting planes, in a.m., p.m. and early morning orbit, on not less than 99 per cent of occasions. This implies provisions for ground segment, instrument and satellite redundancy, and rapid call-up of replacement launches or a.m. and p.m. spares.~~

~~2.4 Other operational/sustained spacecraft on appropriate Low Earth Orbits~~

~~2.4.1 The following capability should be provided:~~
~~(a) High-precision radar altimetry (for ocean surface topography);~~
~~(b) Radio-occultation sounding from non-sun-synchronous orbits;~~
~~(c) Total solar irradiance;~~
~~(d) Dual-angle view infrared imagery (for high-accuracy sea surface temperature measurement);~~
~~(e) Narrow-band visible and near infrared imagers for ocean colour, vegetation and aerosol monitoring;~~
~~(f) High spatial resolution multispectral visible and infrared imagery.~~

~~2.4.2 An altimetry mission on high-precision, inclined orbit should complement the two altimetry missions in sun-synchronous orbits to build a robust ocean surface topography constellation.~~

~~2.4.3 A constellation of dedicated spacecraft with radio-occultation sensors on appropriate orbits should complement the radio-occultation missions on sun-synchronous orbits.~~

~~2.4.4 At least one satellite should perform downward solar irradiance monitoring, with provisions for overlap between consecutive missions in order to maintain measurement continuity.~~

~~2.4.5 A sun-synchronous spacecraft should be maintained on an a.m. orbit with high-accuracy infrared imagery to provide reference measurements of sea surface temperature.~~

~~2.4.6 Continuity should be provided for at least one narrow-band visible and near-infrared imager on a sun-synchronous a.m. orbit to monitor ocean colour, vegetation and aerosols.~~

~~2.4.7 Several sun-synchronous satellites in a.m. orbit should be equipped with high-resolution (10-m class) multispectral visible/infrared imagers to build a constellation providing sufficient coverage of the land surface.~~

~~2.5 Research and development satellites~~

~~2.5.1 Purposes: The main purposes of research and development satellites are:~~
~~(a) To support scientific investigations on atmospheric, oceanic and other environment related processes;~~
~~(b) To test or demonstrate new or improved sensors and satellite systems in preparation for new generations of operational capabilities to meet WMO observational requirements.~~

~~2.5.2 Missions: Observing capabilities should be provided to enable, for instance, the following:~~
~~(a) Observation of the parameters necessary to understand and model the water cycle, the carbon cycle, the energy budget and the chemical processes of the atmosphere;~~
~~(b) Pathfinders for future operational missions should include, for instance: precipitation radars, Doppler lidars, low-frequency microwave radiometers, geostationary microwave imagers and sounders, geostationary narrow-band visible and near-infrared imagers, gravimetric sensors, and imagery missions in high-inclination highly elliptical orbits.~~

~~2.5.3 Although neither long-term continuity of service nor a reliable replacement policy is assured, research and development satellites also provide, in many cases, information of great value for operational use. To this purpose, and in order to promote the early use of new types of data in an operational environment, provisions should be made when relevant to enable near-real-time data availability.~~

~~2.6 Intercalibration system~~

~~2.6.1 Operators of environmental satellites should perform rigorous prelaunch instrument characterization and calibration, including radiance confirmation against an international radiance scale provided by a National Metrology Institute.~~

~~2.6.2 After launch, all passive instruments should be intercalibrated on a routine basis against reference instruments or calibration targets, using established and documented methodologies.~~

~~2.6.3 Spacecraft with at least one high-quality hyperspectral infrared instrument should be maintained in a LEO orbit to provide reference measurements for intercalibration of operational infrared instruments in geostationary or LEO orbit, respectively. Advantage should be taken of satellite collocation to perform instrument intercalibration.~~

~~2.6.4 A range of ground-based calibration targets should be maintained, with precise characterization, in order to support routine visible channel calibration operations.~~

~~2.7 Associated ground segments~~

~~2.7.1 General provisions~~

~~2.7.1.1 Members operating environmental observation satellites should make satellite data available to other Members over the WMO Information System (WIS) in accordance with WIS data management practices, and should inform the Members of the means of obtaining these data through catalogue entries and metadata enabling their meaningful use.~~

~~2.7.1.2 Receiving and processing facilities should provide for the reception of remote-sensing and DCP data from operational satellites and for the processing of quality-controlled environmental observation information, with a view of further near-real-time distribution.~~

~~2.7.1.3 Satellite data archives should include Level 1B, together with all relevant metadata pertaining to the location, orbit and calibration procedures used. The archiving system should be capable of providing online access to the archive catalogue with a browse facility, and description of data formats, and allowing users to download data.~~

~~2.7.2 Data dissemination~~

~~2.7.2.1 All operational environmental observation satellite systems should ensure near-real-time data dissemination of the appropriate datasets, per the requirement of Members, either by direct broadcast or re-broadcast via telecommunication satellites.~~

~~2.7.2.2 In particular, the operational sun-synchronous satellites providing the core meteorological imagery and sounding mission should have direct broadcast capability as follows:~~

~~(a) Direct broadcast frequencies, modulations and formats should allow a particular user to acquire data from either satellite by a single antenna and signal processing hardware. To the extent possible, the frequency bands allocated to meteorological satellites should be used;~~

~~(b) Direct broadcast should be provided through a high data rate stream, such as the high resolution picture transmission or its evolution, to provide meteorological centres with all the data required for numerical weather prediction, nowcasting, and other real-time applications;~~

~~(c) If possible, a low data rate stream should also be provided, such as the low rate picture transmission, to convey an essential volume of data to users with lower connectivity or low-cost receiving stations.~~

~~2.7.2.3 Re-broadcast via telecommunication satellites[4] should complement and supplement direct broadcast services, to facilitate access to integrated data streams including data from different satellites, non-satellite data and geophysical products.~~

~~2.7.3 Data stewardship~~

~~It is essential to preserve long-term, raw data records and ancillary data required for their calibration, reprocessing them as appropriate, with the necessary traceability information to achieve consistent fundamental climate data records. Operators of environmental satellites should provide full description of all steps taken in the generation of satellite products, including algorithms used, specific satellite datasets used, and characteristics and outcomes of validation activities.~~

~~**2.8 User segment**~~

~~2.8.1 Users' stations~~

~~2.8.1.1 All Members should endeavour to install and maintain in their territory at least one system enabling access to digital data from both LEO and geostationary operational satellite constellations, either a receiver of re-broadcast service providing the required information in an integrated way, or a combination of dedicated direct readout stations.~~

~~2.8.1.2 Members requiring access to data from R&D satellites will need to download these data from the appropriate servers, or install a relevant re-broadcast service providing the required information, or install an appropriate direct broadcast user station, if the R&D satellite has such direct broadcast capability.~~

~~2.8.1.3 Data collection platforms: In order to extend the GOS by the use of the data-collection and relay capability of the environmental observation satellites, Members should establish fixed or moving DCP systems, in particular to cover data-sparse areas.~~

~~2.8.2 Education and training~~

~~*2.8.2.1 Centres of Excellence*~~

~~Support should be provided to education and training of instructors in the use of satellite data and capabilities, for example, at specialized Regional Training Centres or other training institutes designated as Centres of Excellence in satellite meteorology, in order to build up expertise and facilities at a number of regional growth points.~~

~~*2.8.2.2 Training strategy*~~

~~Individual environmental satellite operators should focus their assistance, to the extent possible, on one or more of these Centres of Excellence within their service areas and contribute to the Virtual Laboratory for Education and Training in Satellite Meteorology (VLab). The aim of the education and training strategy implemented through the VLab is to systematically improve the use of satellite data for meteorology, operational hydrology and climate applications, with a focus on meeting the needs of developing countries.~~

~~[4] Formerly referred to as advanced dissemination methods (ADM), this technique generally uses digital video broadcast (DVB) standard or its evolution.~~

~~*2.8.2.3 User preparation to new systems*~~

~~For smooth transition to new satellite capabilities, provisions should be made for appropriate preparation of the users through training, guidance to upgrade receiving equipment and processing software, and information and tools to facilitate the development and testing of applications. In addition to working through the VLab, Members should, as appropriate, exploit partnerships with organizations providing education and training in environmental satellite applications, depending on their specific needs.~~

~~2.8.3 Engagement between users and providers~~

~~To achieve the most effective utilization of satellite data, the close engagement between users and providers should be pursued, particularly at a regional level. To this end, each regional association is encouraged to follow systematic steps to document the regional requirements for satellite data access and exchange.~~

~~3. OBSERVATIONS FROM SPACE~~

~~Satellite systems should provide quantitative data and qualitative information enabling, independently, as a constellation, or in conjunction with surface-based observations, the determination of:~~

~~(a) Three-dimension fields of atmospheric temperature and humidity;~~
~~(b) Temperature of sea and land surfaces;~~
~~(c) Wind fields at the ocean surface and aloft;~~
~~(d) Cloud properties (amount, type, top height, top temperature and water content);~~
~~(e) Radiation balance;~~
~~(f) Precipitation;~~
~~(g) Lightning detection;~~
~~(h) Ozone concentration (total column and vertical profile);~~
~~(i) Greenhouse gases;~~
~~(j) Aerosol concentration and properties;~~
~~(k) Volcanic ash cloud monitoring;~~
~~(l) Vegetation characterization;~~
~~(m) Flood and forest fire monitoring;~~
~~(n) Snow and ice cover;~~
~~(o) Ocean colour;~~
~~(p) Wave height, direction and spectra;~~
~~(q) Sea level and surface currents;~~
~~(r) Sea-ice monitoring;~~
~~(s) Solar activity;~~
~~(t) Space environment (electric and magnetic fields, particle flows, electron content).~~

~~Notes:~~

~~1. Information on the principles of Earth observation from space and on the different types of space-based instruments will be included in the Guide to Meteorological Instruments and Methods of Observations (WMO-No. 8), Part IV.~~

~~2. The database on Observing Systems Capability Analysis and Review Tool (OSCAR) provides an indication of the main instruments that are relevant for each specific variable observable from space, as well as the potential performance of each instrument technique for the relevant variables.~~

PART V

QUALITY CONTROL

Note: provisions for quality control of all WIGOS observations, including those of the GOS, are contained in the Manual on WIGOS (WMO-No. xxx)

~~1. BASIC CHARACTERISTICS OF QUALITY CONTROL~~

~~Note:The *Guide on the Global Data-processing System* (WMO-No. 305) is the authoritative reference on all matters related to quality control issues. It should be consulted for more detailed descriptions.~~

~~1.1 Quality control of observational data consists of examination of data at stations and at data centres to detect errors so that data may be either corrected or flagged. A quality control system should include procedures for returning to the source of data to verify them and to prevent recurrence of errors. Quality control is applied in real time, but it also operates in non-real-time, as delayed quality control. Data quality depends on the quality control procedures applied during data acquisition and processing and during preparation of messages, in order to eliminate the main sources of errors and ensure the highest possible standard of accuracy for the optimum use of these data by all possible users.~~

~~1.1.1 Within the framework of the Global Observing System (GOS), quality control shall be a real-time activity which has to be performed prior to the transmission of the observational data on the Global Telecommunication System (GTS).~~

~~Note:See the *Guide to Meteorological Instruments and Methods of Observations* (WMO-No. 8), Part III.~~

~~1.1.2 Quality control shall also be performed on a non-real-time basis, prior to forwarding the observational data for archiving.~~

~~Notes:~~
~~1. Quality control on a real-time basis shall also take place in the Global Data-processing and Forecasting System, prior to the use of the observational data in data processing (i.e. objective analysis and forecasting).~~
~~2. See the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), Volume I – Global Aspects.~~

~~1.2 Quality control shall be applied to all observational data obtained from either the surface-based or the space-based subsystem.~~

~~2. GENERAL PRINCIPLES~~

~~2.1 Responsibility~~

~~2.1.1 The primary responsibility for quality control of all observational data shall rest with the Members from whose Services the observations originated.~~

~~Note:Members should pay due attention to the quality control of observational data at the national level, aiming at the prevention of errors at the observational site, as well as the National Meteorological Centres (NMCs).~~

~~2.1.2 Members shall inform the Secretary-General (for general dissemination) of any special features of their observing systems which may be important in the correct interpretation of the data provided.~~

~~2.2 Relay of data~~

~~Quality control of observational data needed for operational use shall not cause any significant delay in onward transmission on the GTS.~~

~~2.3 Minimum standards~~

~~2.3.1 Members shall implement minimum standards of quality control at all levels for which they are responsible (e.g. observing stations, NMCs, Regional Meteorological Centres (RMCs) and World Meteorological Centres (WMCs).~~

~~Note:Recommended minimum standards of quality control at the level of the observing station and at that of the NMC are given in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), Volume I – Global Aspects, Appendix II-1, Table I.~~

~~2.3.2 Members not capable of implementing these standards should establish agreements with an appropriate RMC or WMC to perform the necessary quality control.~~

APPENDIX

DEFINITIONS

The following terms, when used in this Manual, have the meanings given below. Composite terms have not been defined in this section when their meanings can easily be deduced from those of the elements constituting them. For example, the meaning of the term "synoptic land station" can be constructed logically from the meaning of the terms "synoptic station" and "land station". Other definitions can be found in the *Manual on Codes* (WMO-No. 306), *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), *Manual on the Global Tele-communication System* (WMO-No. 386) and other WMO publications.

Many terms use in this Manual are defined in the Manual on WIGOS (WMO-No. xxx) and are not repeated here.

A. METEOROLOGICAL OBSERVING FACILITIES AND RELATED SERVICES

~~Advanced Dissemination Method (ADM): Dissemination services other than through direct broadcast for satellite sensor, data and products. These advanced methods include: the use of data relay between satellite systems, the use of commercially provided higher data rate services, and the use of services such as the Internet. ADM should complement or supplement direct broadcast services.~~

Aeronautical meteorological station: A station designated to make observations and meteorological reports for use in international air navigation.

Agricultural meteorological station: A station that provides meteorological and biological information for agricultural and/or biological applications. Agricultural meteorological stations are classified as follows:

– Principal agricultural meteorological station: A station that provides detailed simultaneous meteorological and biological information and where research in agricultural meteorology is carried out. The instrumental facilities, the range and frequency of observations in both meteorological and biological fields, and the professional personnel are such that fundamental investigations into agricultural meteorological questions of interest to the countries or Regions concerned can be carried out.

– Ordinary agricultural meteorological station: A station that provides, on a routine basis, simultaneous meteorological and biological information and may be equipped to assist in research into specific problems; in general the programme of biological or phenological observations for research will be related to the local climatic regime of the station.

– Auxiliary agricultural meteorological station: A station that provides meteorological and biological information. The meteorological information may include such items as soil temperature, soil moisture, potential evapotranspiration, detailed information on the very lowest layer of the atmosphere; the biological information may cover phenology, onset and spread of plant diseases, etc.

– Agricultural meteorological station for specific purposes: A station set up temporarily or permanently that provides meteorological data for specific agricultural purposes.

Aircraft Communication Addressing and Reporting System (ACARS): Automated aviation meteorological data collection system from aircraft fitted with appropriate software packages. Similar in function to ASDAR.

Aircraft Meteorological Data Relay (AMDAR): The collective name for the automated aviation meteorological data collection systems called ASDAR and ACARS from aircraft fitted with appropriate software packages.

~~Aircraft meteorological station: A meteorological station situated on an aircraft.~~

Aircraft to Satellite Data Relay (ASDAR): Auto-mated aviation meteorological data collection system from aircraft fitted with appropriate software packages. Similar in function to ACARS.

Anchored platform station: An observing station on a platform anchored in deep water.

Atmospherics detection station: A station contributing observations to an atmospheric detection system.

Atmospherics detection system: An instrumental system consisting of a number of stations for the detection and location of atmospherics.

Automated aircraft meteorological system: A series of devices integrated into the instrumentation of an aircraft, which records and/or transmits observations automatically.

Automatic weather station (AWS): Meteorological station at which observations are made and transmitted automatically.

Auxiliary ship station: A mobile ship station, normally without certified meteorological instruments, that transmits reports in code form or in plain language, either as routine or on request, in certain areas or under certain conditions.

Climatological station: A station whose observations are used for climatological purposes. Climatological stations are classified as follows:

– Reference climatological station: A climatological station the data of which are intended for the purpose of determining climatic trends. This requires long periods (not less than 30 years) of homogeneous records, where human-induced environmental changes have been and/or are expected to remain at a minimum. Ideally, the records should be of sufficient length to make possible the identification of secular changes of climate.

– Principal climatological station: A climatological station at which hourly readings are taken, or at which observations are made at least three times daily in addition to hourly tabulation from autographic records.

– Ordinary climatological station: A climatological station at which observations are made at least once daily, including daily readings of extreme temperature and of amount of precipitation.

– Climatological station for specific purposes: A climatological station established for the observation of a specific element or elements.

Coastal station: A station on a coast that may be able to make some observations of conditions at sea.

~~Data collection platform (DCP): A fixed or moving platform on land, sea or in the air that transmits data via satellite to a collection centre.~~

~~Direct broadcast service: A broadcast service, provided by some operational environmental observation satellites, that transmits satellite sensor data and products in real-time for reception by ground stations within radio range of the satellite.~~

Drifting automatic sea (drifting buoy) station: A floating automatic ~~surface synoptic~~ station that is free to drift under the influence of wind and current.

Environmental data buoy station: A fixed or drifting buoy which records or transmits environmental and/or marine data.

Environmental observation satellite: An artificial Earth satellite providing data on the Earth system which are of benefit to WMO Programmes.

Note:These data support a variety of disciplines including, but not limited to, meteorology, hydrology, climatology, oceanography, climate and global change related disciplines.

Fixed platform station: An observing station on a platform at a fixed site in shallow water.

Fixed sea station: An ocean weather ship or a station situated on a lightship, a fixed or anchored platform, or a small island, or in certain coastal areas.

~~Geostationary satellite: A type of meteorological satellite orbiting the Earth at an altitude of approximately 36 000 km with the angular velocity of the Earth and within the equatorial plane, thus providing nearly continuous information in an area within a range of about 60° geocentric angle from a 销fixed subsatellite point located at the Equator.~~

~~Global Atmosphere Watch (GAW) station: A station that provides observational data and other information on the chemical composition and physical characteristics of the background atmosphere.~~

Global Climate Observing System Reference Upper-Air Network (GRUAN) station: An upper-air station included in the network of stations specially selected and certified to provide long-term high quality climate records.

Global Climate Observing System Surface Network (GSN) station: A land station included in the specially selected network of stations to monitor daily and large-scale climate variability on a global basis.

Global Climate Observing System Upper-air Network (GUAN) station: An upper-air station included in the specially selected global baseline network of upper-air stations to meet the requirements of the Global Climate Observing System.

Global Data-processing and Forecasting System (GDPFS): The coordinated global system of meteorological centres and arrangements for the processing, storage and retrieval of meteorological information within the framework of the World Weather Watch.

~~Global Observing System (GOS): The coordinated system of methods and facilities for making meteorological and other environmental observations on a global scale in support of all WMO Programmes, particularly the World Weather Watch and the World Climate Programme; the system is comprised of operationally reliable surface-based and space-based subsystems. The objective is to assure continuity of service.~~

Global Telecommunication System (GTS): The coordinated global system of telecommunication facilities and arrangements for the rapid collection, exchange and distribution of observational and processed information within the framework of the World Weather Watch.

Ice-floe station: An observing station on an ice floe.

Island station: A station on a small island on which conditions are similar to those in the marine environment and from which some observations of conditions at sea can be made.

Land station: An observing station situated on land.

Lightship station: A surface synoptic station situated aboard a lightship.

Meteorological element: Atmospheric variable or phenomenon which characterizes the state of the weather at a specific place at a particular time (see Section B below).

~~Meteorological observation (Observation): The evaluation or measurement of one or more meteorological elements.~~

~~Meteorological observing network: A group of observing stations spread over a given area for a specific purpose.~~

~~Meteorological observing station (Station): A place where meteorological observations are made with the approval of the Member or Members concerned.~~

Meteorological reconnaissance aircraft station: A meteorological station on an aircraft equipped and assigned for the specific purpose of making meteorological observations.

Meteorological reconnaissance flight: An aircraft flight for the specific purpose of making meteorological observations.

~~Meteorological report (Report): A statement of observed meteorological conditions related to a specified time and location.~~

Meteorological rocket station: A station equipped to make atmospheric soundings by rockets.

~~Meteorological satellite: An artificial Earth satellite making meteorological observations and transmitting these observations to Earth.~~

Mobile sea station: A station aboard a mobile ship or an ice floe.

National Meteorological Centre (NMC): A centre responsible for carrying out national functions including those under the World Weather Watch.

~~Observing station: Any station making meteorological and related environmental observations.~~

Ocean weather station: A station aboard a suitably equipped and staffed ship that endeavours to remain at a fixed sea position and that makes and reports surface and upper-air observations and may also make and report subsurface observations.

~~Operational satellite: One of a series of environmental observation satellites with the primary purpose to routinely provide observations and services of a consistent standard over a long period. Resources are committed to ensure continuity of services thus permitting the establishment of a reliable satellite replacement policy.~~

Ozone sounding station: A station at which observations of atmospheric ozone are made.

Pilot-balloon observation: A determination of upper winds by optical tracking of a free balloon.

Pilot-balloon station: A station at which upper winds are determined by optical tracking of a free balloon.

Planetary boundary layer: The lowest layer in the atmosphere, usually taken to be up to 1 500 m, in which meteorological conditions are affected significantly by the Earth's surface.

Planetary boundary-layer station: A station equipped to provide detailed meteorological data on the planetary boundary layer.

~~Polar-orbiting satellite: A type of environmental observation satellite with nearly circular, nearly polar orbit. The combination of satellite motion and the Earth's rotation beneath the orbit enables the collection of overlapping strips of satellite data (swaths up to 3 000 km wide) from pole to pole. The satellite's altitude or inclination defining the orbit may be selected in such a way to be sun-synchronous and provide global coverage. Sun-synchronous implies that the satellite will pass over a given geographic position at the same local sun-time each day.~~

Precipitation station: A station at which observations of precipitation only are made.

Radiation station: A station at which observations of radiation are made.

– Principal radiation station: A radiation station the observing programme of which includes at least the continuous recording of global solar radiation and of sky radiation and regular measurements of direct solar radiation.

– Ordinary radiation station: A radiation station whose observing programme includes at least the continuous recording of the global solar radiation.

Note: The terminology of radiation quantities and measuring instruments is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8).

Radiosonde observation: An observation of meteorological elements in the upper air, usually atmospheric pressure, temperature and humidity, by means of a radiosonde.

Note:The radiosonde may be attached to a balloon, or it may be dropped (dropsonde) from an aircraft or a rocket.

Radiosonde station: A station at which observations of atmospheric pressure, temperature and humidity in the upper air are made by electronic means.

Radiowind observation: A determination of upper winds by tracking of a free balloon by electronic means.

Radiowind station: A station at which upper winds are determined by the tracking of a free balloon by electronic means.

Rawinsonde observation: A combined radiosonde and radiowind observation.

Rawinsonde station: A combined radiosonde and radiowind station.

Reference level data: Data for a specified level, normally 1 000 hPa, which enable absolute heights to be ascribed to satellite temperature-sounding data.

Regional Basic Climatological Network (RBCN): A network composed of climatological stations with a specified observational programme within a WMO Region, which is a minimum regional requirement to permit Members to fulfil their responsibilities within the World Weather Watch and also serve as a target list for WWW monitoring of climatological data.

Regional Basic Synoptic Network (RBSN): A network composed of synoptic stations with a specified observational programme within a WMO Region, which is a minimum regional requirement to permit Members to fulfil their responsibilities within the World Weather Watch and in the application of meteorology.

Regional Meteorological Centre (RMC): A centre of the Global Data-processing and Forecasting System which has the primary purpose of issuing meteorological analyses and prognoses on a regional scale.

Regional Specialized Meteorological Centre (RSMC): A centre of the Global Data-processing and Forecasting System that has the primary purpose of issuing meteorological analyses and prognoses on a regional scale for a specified geographical area or of providing products and related information in a designated field of activity specialization.

~~Research and development satellite: An environmental observation satellite with the primary purpose of acquiring a defined set of research data; testing new instrumentation and/or improving existing sensors and satellite systems; and/or it may provide information for operational use, but has limitations due to the lack of a commitment to ensure continuity of service or a reliable satellite replacement policy; and also due to non-consistent modes of operations.~~

Research and special-purpose vessel station: A vessel making voyages for research or other purposes and which is recruited to make meteorological observations during the voyages.

~~Satellite communication services requirements: Requirements for services using environmental observation satellites including, but not limited to, direct broadcast of data, radio relay of environmental data collected by automatic sensor platforms, and search and rescue transmissions.~~

~~Satellite data requirements: Those data specified as performance goals for an operational environmental observation satellite system. At a minimum, environmental observation satellite data requirements are defined in terms of spatial, spectral and temporal resolution, geographic extent, timeliness, and measurement and location accuracy.~~

~~Note:These data requirements are routinely reviewed to identify common needs in order to consolidate the design of the satellite's instrument payload, and to identify requirements that could be met more effectively either by surface or space-based observing systems.~~

~~Satellite operator: An entity (Member of WMO or international organization) that manages, and/or operates environmental observation satellites which are of benefit to WMO Programmes.~~

Sea station: An observing station situated at sea.

Selected ship station: A mobile ship station that is equipped with sufficient certified meteorological instruments for making observations and that transmits the required observations in the appropriate code form for ships.

~~Space-based subsystem: One of the two major components of the Global Observing System composed primarily of environmental observation satellites in polar and geostationary orbits.~~

Special report: A report made at a non-standard time of observation when specified conditions or changes of conditions occur.

Special station: A station for a special purpose as specified in Part III, paragraph 1, of this Manual.

Standard time of observation: A time specified in this Manual for making meteorological observations.

Note:The term Coordinated Universal Time (UTC) is used in this Manual.

Supplementary ship station: A mobile ship station that is equipped with a limited number of certified meteorological instruments for making observations and that transmits the required observations in an abbreviated code form for ships.

~~Surface-based subsystem: One of the two major components of the Global Observing System composed of all non-spaced-based observing stations.~~

Surface observation: A meteorological observation, other than an upper-air observation, made on the Earth's surface.

Surface station: A surface location from which surface observations are made.

Synoptic observation: A surface or upper-air observation made at a standard time.

Synoptic station: A station at which synoptic observations are made.

Tide-gauge station: A station at which tidal measurements are made.

Upper-air observation: A meteorological observation made in the free atmosphere either directly or indirectly.

Upper-air report: A report of an upper-air observation.

Upper-air station: A surface location from which upper-air observations are made.

Upper-wind observation: An observation at a given height or the result of a complete sounding of wind direction and speed in the atmosphere.

Weather radar station: A station making observations by weather radar.

World Meteorological Centre (WMC): A centre of the Global Data-processing and Forecasting System which has the primary purpose of issuing meteorological analyses and prognoses on a global scale.

World Weather Watch (WWW): The worldwide, coordinated, developing system of meteorological facilities and services provided by Members for the purpose of ensuring that all Members obtain the meteorological and other environmental information they require both for operational work and for research. The essential elements of the World Weather Watch are the:

– Global Observing System (GOS);

– Global Data-processing and Forecasting System (GDPFS);

– Global Telecommunication System (GTS).

B. METEOROLOGICAL ELEMENTS AND OTHER OBSERVED VARIABLES

Aerosol: Substances, divided into solid particles or liquid droplets, held in suspension in the atmosphere.

Air temperature: The temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation.

Aircraft icing: Formation of ice, rime or hoar frost on an aircraft.

Atmospheric pressure: Pressure (force per unit area) exerted by the atmosphere on any surface by virtue of its weight; it is equivalent to the weight of a vertical column of air extending above a surface of unit area to the outer limit of the atmosphere.

– Pressure tendency: Character and amount of a station pressure change over three hours (over 24 hours in tropical regions).

– Characteristic of pressure tendency: Shape of the curve recorded by a barograph during the three-hour period preceding an observation.

Cloud: A hydrometeor consisting of minute particles of liquid water of ice, or of both, suspended in free air and usually not touching the ground.

– Cloud amount: The fraction of the sky covered by the clouds of a certain genus, species, variety, layer, or combination of clouds.

– Height of cloud base: Height above the Earth surface of the base of the lower cloud layer whose amount exceeds a specific value.

– Direction and speed of cloud movement: Direction from which the cloud is coming and the horizontal component of its speed.

– Cloud type (classification): Type or variety of cloud as described and classified in the International Cloud Atlas.

Contrail: Cloud which forms in a wake of an aircraft when the air at flight level is sufficiently cold and moist.

Dew point: Temperature to which a volume of air must be cooled at constant pressure and constant moisture in order to reach saturation.

Humidity: Water vapour content of the air.

Precipitation: Hydrometeor consisting of a fall of an ensemble of particles. The forms of precipitation are: rain, drizzle, snow, snow grains, snow pellets, diamond dust, hail and ice pellets.

Precipitation chemistry: Nature and amount of the impurities dissolved or suspended in the precipitation.

Sea ice: Any form of ice found at sea which has originated from the freezing of sea water.

Sea surface temperature: Temperature of the surface layer of the sea.

Soil moisture: Moisture contained in that portion of the soil which lies above the water table, including the water vapour contained in the soil pores.

Soil temperature: Temperature observed at different depths in the soil.

Solar radiation: Energy emitted by the sun considered as short-wave radiation with wavelengths between 0.29 and 4μm.

State of ground: The characteristics of the surface of the ground, especially resulting from the effect of rain, snow and temperatures near freezing point.

Sunshine duration: The sum of the time, during a given period, for which the direct solar irradiance exceeds 120 W/m^2.

Turbidity: Reduced transparency of the atmosphere to radiation (especially visible) caused by absorption and scattering by solid or liquid particles other than clouds.

Turbulence: Random and continuously changing air motions which are superposed on the mean motion of the air.

Upper wind: The wind speed and direction at various levels in the atmosphere, above the domain of surface weather.

Visibility: Greatest distance at which a black object of suitable dimensions can be seen and recognized against the horizon sky during daylight or could be seen and recognized during the night if the general illumination were raised to the normal daylight level.

Wave height: The vertical distance between the trough and crest of the wave.

Wave period: Time between the passage of two successive wave crests past a fixed point.

Waves, direction of movement of: Direction from which the waves arrive at a given point.

Weather: State of the atmosphere at a particular time, as defined by the various meteorological elements.

– Present weather: Weather existing at a station at a time of observation.

– Past weather: Predominant characteristic of the weather which had existed at an observing station during a given period of time.

Wind direction: Direction from which the wind blows.

Wind speed: Ratio of the distance covered by the air to the time taken to cover it.

Note: A more detailed list of geophysical parameters used to state observational data requirements and their associated definitions is contained in the *Guide to the Global Observing System* (WMO-No. 488).

Recommendation 12 (CBS-Ext.(2014))

RADIO FREQUENCIES FOR METEOROLOGICAL AND RELATED ENVIRONMENTAL ACTIVITIES

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(1) Resolution 4 (Cg-XV) – Radio frequencies for meteorological and related environmental activities,

(2) Resolution 11 (EC-64) – Radio frequencies for meteorological and related environmental activities,

(3) Resolution 9 (EC-65) – Preserving the radio-frequency spectrum for meteorological and related environmental activities at the World Radiocommunication Conference 2015,

Noting:

(1) That the Executive Council at its sixty-sixth session agreed to keep as a priority issue Resolution 9 (EC-65),

(2) That the WMO observing systems comprise a wide number of different radio-based systems/applications operating in different radio services on a global and regional basis,

(3) That the World Radiocommunication Conference of the International Telecommunication Union is the decision-making forum for the regular review and revision of the Radio Regulations, an international treaty related to setting radio-frequency allocations and regulatory provisions applied to all global and regional radio services,

Considering:

(1) The increasing demand for meteorological and environmental data used by National Meteorological and Hydrological Services in weather forecasting, climate monitoring, protection of the environment, and detection and mitigation of the negative effects of disasters,

(2) The important role of radio-based meteorological and environmental monitoring systems/applications in obtaining and disseminating meteorological data,

(3) The crucial importance of the allocation of radio-frequency bands employed by space-based and surface-based WMO observing systems and the need for their protection from harmful interference,

Recommends that Resolution 4 (Cg-XV) be updated to reflect the continued importance of radio-frequency coordination in the seventeenth financial period, and that the draft resolution based on Resolution 4 (Cg-XV), as contained in the annex to the present recommendation, be presented for consideration by the Seventeenth World Meteorological Congress.

Annex to Recommendation 12 (CBS-Ext.(2014))

DRAFT REVISION OF RESOLUTION 4 (Cg-XV) – RADIO FREQUENCIES FOR METEOROLOGICAL AND RELATED ENVIRONMENTAL ACTIVITIES

Resolution ~~4~~X (Cg-~~XV~~17)

RADIO FREQUENCIES FOR METEOROLOGICAL AND RELATED ENVIRONMENTAL ACTIVITIES

THE CONGRESS,

Noting:

(1) The WMO Strategic and Operating Plans~~ and the United Nations Millennium Development Goals~~,

(2) Resolution ~~3~~4 (Cg-X~~I~~V) – Radio-frequencies for meteorological and related environmental activities,

(3) The current radio frequency allocations and regulatory provisions related to the meteorological aids, meteorological satellite, Earth exploration-satellite and radiolocation (weather and wind profiler radars) services in the Radio Regulations of ITU,

(4) The outcome of the ITU World Radiocommunication Conferences (WRC)~~, especially WRC-2000 and WRC-03~~,

(5) The agenda of the forthcoming ITU World Radiocommunication Conferences ~~(WRC-07)~~ and related WMO positions submitted during the ITU preparatory process,

Considering:

(1) The prime importance of the specific radiocommunication services for meteorological and related environmental activities required for the prevention, detection, early warning and mitigation of natural and technological (man-made) disasters, the safety of life and property, the protection of the environment, climate change studies and scientific research,

(2) The importance of information provided by the Earth-exploration systems including meteorological systems for a wide range of economic activities such as agriculture, transportation, construction, tourism, etc.,

(3) The crucial importance of the allocation of suitable radio frequency bands for the operation of surface-based meteorological observing systems, including in particular radiosondes, weather radars, wind profiler radars,

(4) The crucial importance of the allocation of suitable radio-frequency bands for the operation of Meteorological and R&D satellites, including remote sensing, data collection and data distribution links,

Stressing that some radio-frequency bands are a unique natural resource due to their special characteristics and natural radiation enabling spaceborne passive sensing of the atmosphere and the Earth surface, that deserve adequate allocation to the Earth exploration satellite service (passive) and absolute protection from interference,

Expresses its serious concern at the continuing threat to several frequency bands allocated to the meteorological aids, meteorological satellite, Earth exploration-satellite and radiolocation (weather and wind profiler radars) services posed by the development of other radiocommunication services,

Requests the Commission for Basic Systems to pursue the continuous review of regulatory and technical matters related to radio frequencies for operational and research meteorological and related environmental activities, and preparation of guidance and information for NMHSs, in coordination with other technical commissions, especially CIMO, and in liaison with other relevant international bodies, in particular the Coordination Group for Meteorological Satellites;

Urges all Members to do their utmost to ensure the availability and protection of suitable radio frequency bands required for meteorological and related environmental operations and research, and in particular:

(1) To ensure that their national radiocommunication administrations are fully aware of the importance of and requirements for radio frequencies for meteorological and related activities, and to seek their support in the ITU World Radiocommunication Conferences and Radiocommunication Sector activities;

(2) To participate actively in the national, regional and international activities on relevant radiocommunication regulatory issues and, in particular, to involve experts from their Services in the work of relevant regional radiocommunication organizations and of ITU-R, especially ITU-R Study Group 7 on Science Services;

(3) To register adequately with their national radiocommunication administrations all radiocommunication stations and radio frequencies used for meteorological and related environmental operations and research;

Appeals to ITU and its Member Administrations:

(1) To ensure the availability and absolute protection of the radio-frequency bands which, due to their special physical characteristics, are a unique natural resource for spaceborne passive sensing of the atmosphere and the Earth surface~~; in this regard, the exclusive 23.6–24 GHz passive band that is associated with a water vapour absorption line is~~ and are of crucial importance for weather, water and climate research and operations;

(2) To give due consideration to the WMO requirements for radio frequency allocations and regulatory provisions for meteorological and related environmental operations and research;

(3) To pay special attention to the WMO positions related to WRC~~-07~~ agenda, in the light of Appeals (1) and (2) above;

Requests the Secretary-General:

(1) To bring this resolution to the attention of all concerned, including the International Telecommunication Union;

(2) To pursue as a matter of high priority the coordination role of the Secretariat in radio frequency matters, especially with ITU-R, including participation of WMO in ITU-R Radiocommunication Study Groups, conference preparatory meetings and World Radiocommunication Conferences;

(3) To facilitate the coordination between National Meteorological and Hydrological Services and their national radiocommunication administrations, particularly in preparing the ITU World Radiocommunication Conferences, by providing appropriate information and documentation;

(4) To assist the Commission for Basic Systems in the implementation of this resolution.

Note: This resolution replaces Resolution ~~3~~4 (Cg-X~~I~~V), which is no longer in force

Recommendation 13 (CBS-Ext.(2014))

GUIDE FOR NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES PARTICIPATION IN RADIO-FREQUENCY COORDINATION

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 4 (Cg-XV) – Radio frequencies for meteorological and related environmental activities,

(2) Resolution 11 (EC-64) – Radio frequencies for meteorological and related environmental activities,

(3) Resolution 9 (EC-65) – Preserving the radio-frequency spectrum for meteorological and related environmental activities at the World Radiocommunication Conference 2015,

Noting further:

(1) The importance of increased involvement of National Meteorological and Hydrological Services (NMHSs) in national frequency policy development to take into consideration the dependence of services operated by NMHSs on observation and communications systems in order to meet national priorities, including the provision of forecasts and warning services and for climate monitoring,

(2) The need for guidance on how NMHSs could be more effectively involved in the national, regional and global development and maintenance of the International Telecommunication Union Radiocommunication Sector's Radio Regulations that govern the use of radio frequency,

Recommends that the Guide for National Meteorological and Hydrological Services Participation in Radio-frequency Coordination, as given in the annex to the present recommendation, be adopted in all WMO official languages.

Annex to Recommendation 13 (CBS-Ext.(2014))

GUIDE FOR NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES PARTICIPATION IN RADIO-FREQUENCY COORDINATION

EXECUTIVE SUMMARY

Purpose of this Guide

1. The Guide for National Meteorological and Hydrological Services (NMHSs), hereafter referred to as this "Guide", has been prepared to assist Members in addressing the requirements of Resolution 4 (Cg-XV). The International Telecommunication Union (ITU), in particular its Radiocommunication sector (ITU-R), has the global responsibility for facilitating the global management of the radio-frequency spectrum and satellite orbits.

2. The Guide provides the general description of ITU's main processes related to radio-frequency coordination, regional structure and regulatory framework that governs the use of radio-

frequency spectrum globally[1] and guides the national management of radio-frequency spectrum as well as management of satellite orbits. More detailed information on which frequencies are important to meteorology and related activity is available in the WMO/ITU joint publication[2] on the "Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction."

3. **Resolution 4 of World Meteorological Congress XV**[3] and **Resolution 11 (EC-64)**[4] highlight the importance of radio frequencies for meteorological and related environmental activities. They urge all WMO Members to do their utmost to ensure the availability and protection of suitable radio-frequency bands required for meteorological and related environmental operations and research, and in particular:

(1) To ensure that their national radiocommunication administrations are fully aware of the importance of and requirements for radio frequencies for meteorological and related activities, and to seek their support in the ITU World Radiocommunication Conferences and Radiocommunication Sector activities;

(2) To participate actively in the national, regional and international activities on relevant radiocommunication regulatory issues and, in particular, to involve experts from their Services in the work of relevant regional radiocommunication organizations and of ITUR, especially ITUR Study Group 7 on Science Services;

(3) To register adequately with their national radiocommunication administrations all radiocommunication stations and radio frequencies used for meteorological and related environmental operations and research.

Regulatory Structure of ITU

4. ITU-R maintains its regulation framework that consists of agreed regulations, procedures, rules, international standards (ITU-R Recommendations in the ITU terminology) and other documents relating to the radio-frequency spectrum and satellite orbits management. The main part of this framework is the ITU Radio Regulations (RR). The RR, like WMO Technical Regulations, is an international treaty. The regulated frequency range (8.3 KHz to 3 000 GHz) is segmented into smaller bands that are allocated to over 40 defined Radio Services. The most relevant Radio Services to WMO include the: meteorological aids service (MetAids); meteorological-satellite service (MetSat); Earth exploration-satellite service (EESS) and radiolocation service (RLS) – see sub-section 2.2. For a radio system or application to seek protection from interference from other systems or applications, it must be attributed to a known Radio Service.

5. RR Article 5 contains the international Table of Frequency Allocations for all frequencies between 8.3 KHz and 3000 GHz based on one row for each band divided into one to three columns. There is one column for each of the three ITU Regions (see Figure 3). ITU Region 1 incorporates WMO Regions I and VI plus the northern parts of Region II. ITU Region 2 incorporates WMO Regions III and IV plus Greenland. ITU Region 3 covers the southern half of WMO Region II and most of Region V.

6. Allocations to the radio services are made at World Radiocommunication Conferences (WRCs) which meet every three to four years. Allocations are made either on PRIMARY or secondary basis where services operating on secondary allocations shall cause no harmful interference to, nor claim protection from, services operating in the PRIMARY allocations. Where multiple services are operating in the same PRIMARY allocation, the stations of these services

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[1] The further details on the development and modification of the radio-frequency management framework on the worldwide basis are provided in the publication "WMO Strategy on Radio-Frequency Protection for Meteorology" (http://wis.wmo.int/file=1029).

[2] "Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction." http://www.itu.int/en/publications/ITU-R/pages/publications.aspx?parent=R-HDB-45-2008&media=electronic

[3] Resolution 4 (Cg-XV) – http://www.wmo.int/pages/prog/www/TEM/WMO_RFC/Res4_en.html

[4] Resolution 11 (EC-64) – ftp://ftp.wmo.int/Documents/PublicWeb/mainweb/meetings/cbodies/governance/executive_council_reports/english/pdf/64_session_1092_part1_en.pdf

must coordinate with each other to ensure that they do not cause harmful interference to each other. When documenting allocations in the RR Tables, PRIMARY allocations are always entered in UPPER CASE, while secondary allocations are written in normal sentence (lower) case.

7. ITU-R also carries out studies and approves international standards on radiocommunication matters (ITU-R Recommendations in the ITU terminology). It works through world and regional Radiocommunication conferences, the Radio Regulation Board (RRB), Radiocommunication Assemblies (RA), Radiocommunication Study Groups and the Radiocommunication Bureau (BR). BR in cooperation with administrations implements coordination and recording procedures for space and terrestrial wireless systems, networks and stations.

8. Member-States of ITU have established six regional telecommunication organizations that formally are not part of the regulatory development process, but play a significant role in world and regional preparation for world radiocommunication conferences. These regional telecommunication organizations coordinate and prepare common proposals related to different aspects of spectrum management including proposals on worldwide and regional allocations for consideration at WRC. The organizations are the:

(a) African Telecommunication Union (ATU);

(b) Arab Spectrum Management Group (ASMG);

(c) Asia-Pacific Telecommunity (APT);

(d) European Conference of Postal and Telecommunication Administrations (CEPT);

(e) Inter-American Telecommunication Commission (CITEL); and

(f) Regional Commonwealth in the Field of Communications (RCC).

9. ITU Member-States have voting rights in the WRCs, but these regional organizations have no such rights. Nevertheless they carry a lot of weight in the decision making process. It is essential that national and regional bodies are fully aware of the impact of decisions on Earth observations and other WMO activities.

10. Coordination of frequency assignments of radiocommunication systems, stations and applications belonging to terrestrial and space radio services is one of the most important methods providing the way for the effective operations of all radio systems and the optimal use of radio-frequency spectrum and satellite orbits. Coordination of a system/station/application in many cases is not only mandatory in accordance with national and international regulations and rules but also necessary for obtaining national/international recognition, and as a result, protection from harmful interference from frequency assignments of the existing and future stations/systems that will support successful operation of this system/station/application in particular and the WMO Integrated Global Observing System in general.

WMO involvement in ITU-R

11. WMO is an observer in ITU-R and through the work of CBS Steering Group on Radio-frequency Coordination (SG-RFC) members is a regular contributor to ITU-R Study Groups in WRC processes. WMO's input is well respected within the ITU-R technical activities. Unfortunately, WMO does not get a vote on WRC decisions. SG-RFC members also represent WMO requirements when registered as a WMO representative or as a part of their national delegation at many of the ITU meetings and some of the six regional groups. This is important for ensuring that the meteorological-related requirements are taken into consideration in the establishment of new or modification of existing provisions of the RR. Similarly, some SG-RFC members have an input through their own administrations and organizations to national radio-frequency coordination and management processes.

12. Although ITU has Sector Members such as telecommunication companies, operators, equipment manufacturers, etc., WRC decisions on changes to the RR are made by ITU

Member-States. However, many Member States include industry representatives in their delegations as well as representatives from their regulatory bodies. In this way, unlike within the WMO infrastructure, industry has a very direct and effective influence on WRC decisions.

13. NMHSs are encouraged to use this Guide to help them understand the organization and processes that make up the radio-frequency coordination and management. The aim is for NMHSs to take advantage of CBS and regional frequency coordination expertise to become more effective in ensuring the radio-frequency services that their present and future basic observations and systems depend on are able to be protected from interference that negatively impacts on their functioning. This Guide should be used in conjunction with the WMO/ITU Handbook on the "Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction".[5]

1. INTRODUCTION

1. Radio-frequency spectrum and satellite orbits are a valuable and limited natural resource employed by different radio-based systems providing the tremendous opportunities for social development of the modern society. Technological progress has continually opened doors to a variety of new radio applications that have spurred interest in, and demand for spectrum. Dependence on radio communications in one form or another has grown dramatically in recent years, and the growth in the number and variety of applications - many of them bandwidth hungry - and the huge expansion in user expectations place ever increasing demands on the radio spectrum.

2. Many services, systems and applications make extensive use of the radio spectrum. These include fixed and mobile radiocommunication systems, broadcasting, aviation, railway and maritime transport, defence, medical electronics, emergency services, remote control and monitoring, radio astronomy, Earth-exploration and space research systems, as well as many other applications.

3. The access to the spectrum is extremely important for Earth observations, weather forecasting, climate monitoring and climate change prediction. Certain frequencies are unique to particular environmental elements and can be monitored passively provided the signals are not overwhelmed by emissions of other radio-frequency users operating in or around that band. Similarly, active sensors based on the use of a certain radio frequency are also subject to interference from other radio systems making them unusable in some circumstances.

4. However, there is almost no absolutely free radio-frequency spectrum in populated areas. Different types of radio stations use the same frequencies and in order to operate efficiently technical parameters of these stations should be selected and tuned in such a way that their emissions would not create interference above the specified level; otherwise it may lead to the situation where not one of them is operating in accordance with technical requirements and none of them would be able to implement the required function.

5. That is why there is a need to properly regulate usage of radio-frequency spectrum by different systems/applications (including meteorological) in order to avoid harmful interference and to implement relevant procedures for the effective use of the spectrum. International and regional agreements, national laws, other documents, procedures and activities related to effective use of radio-frequency spectrum and satellite orbits form the spectrum management system (SMS). Radio-frequency coordination activities are part of the processes carried out in the framework of SMS.

6. The meteorological community also makes extensive use of radio-frequency spectrum by meteorological radio-based systems and applications that obtain environmental information employed for weather forecasting, environment monitoring, natural disaster prediction, detection, early warning and for planning and management of disaster relief operations. Technical details on

[5] "Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction." http://www.itu.int/en/publications/ITU-R/pages/publications.aspx?parent=R-HDB-45-2008&media=electronic

the use of spectrum for environmental monitoring are available in the WMO/ITU joint publication, the Handbook on the "Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction".[6]

7. This Guide describes the basic concepts of radio-frequency coordination process on international, regional and national level that is necessary for effective non-interference operation of different kinds of radio equipment including meteorological systems and applications. It includes some a suggested approach for NMHSs to improve their own effectiveness in influencing spectrum management at national and international levels, but could be used as guidelines by any of the meteorological community.

8. This Guide has been developed by Steering Group on Radio-Frequency Coordination[7] (SG-RFC) working in the framework of the WMO Commission for Basic Systems (CBS).

2. WHAT IS FREQUENCY ASSIGNMENT COORDINATION AND WHY IS IT NECESSARY?

2.1 Frequency Coordination

9. There is no definition of the term "coordination" in the main international agreement regulating the use of radio-frequency spectrum and satellite orbits - the Radio Regulations[8] (RR) developed and maintained by the International Telecommunication Union[9] (ITU). However, coordination should be understood as a process followed by users of radio-frequency spectrum in order to avoid potential harmful interference between new and existing wireless systems/stations/applications.

10. When is coordination necessary? The main purposes of coordination are:

(a) To allow effective operation of already existing radio stations/system as well as the new one;

(b) To provide recognition of this new station/system in the future. That practically means to provide protection from harmful interference[10] of stations/systems, which could be brought into the use in the future.

11. The coordination process involves:

(a) The exchange of technical and operational data of existing and earlier submitted (usually data of the existing and earlier assignments are obtained from the relevant national and/or international data base) and new frequency assignment(s) of radio stations/systems;

(a) Studies of potential interference effects between existing and new frequency assignment(s);

(c) Correspondence between spectrum management authorities (national and/or international, depending on the case) and spectrum users and between users themselves regarding new proposals and, as necessary;

(d) Adjustment of technical parameters and/or re-design of proposed systems/applications in order to allow effective operation of new and existing radio systems/applications.

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[6] "Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction." http://www.itu.int/en/publications/ITU-R/pages/publications.aspx?parent=R-HDB-45-2008&media=electronic

[7] See at: http://www.wmo.int/pages/prog/www/TEM/WMO_RFC/meetings-en.html.

[8] See at: http://www.itu.int/pub/R-REG-RR/en (*Hereafter all references made to the Radio Regulations, Edition of 2012*).

[9] See at: http://www.itu.int

[10] RR No.**1.169** defines the harmful interference as follows:

"*harmful interference*: Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with Radio Regulations." *(RR No. **1.169** means provision No. **1.169** of the Radio Regulations. This format will be used for further references to the relevant provisions of RR).*

12. It is essential before starting the coordination process to select proper technical/operational characteristics/parameters and avoid serious mistakes that may prevent a successful coordination from the beginning. The working technical/operational characteristics/parameters of a future station/system should be consistent with international and/or national spectrum management regulations/rules. For example:

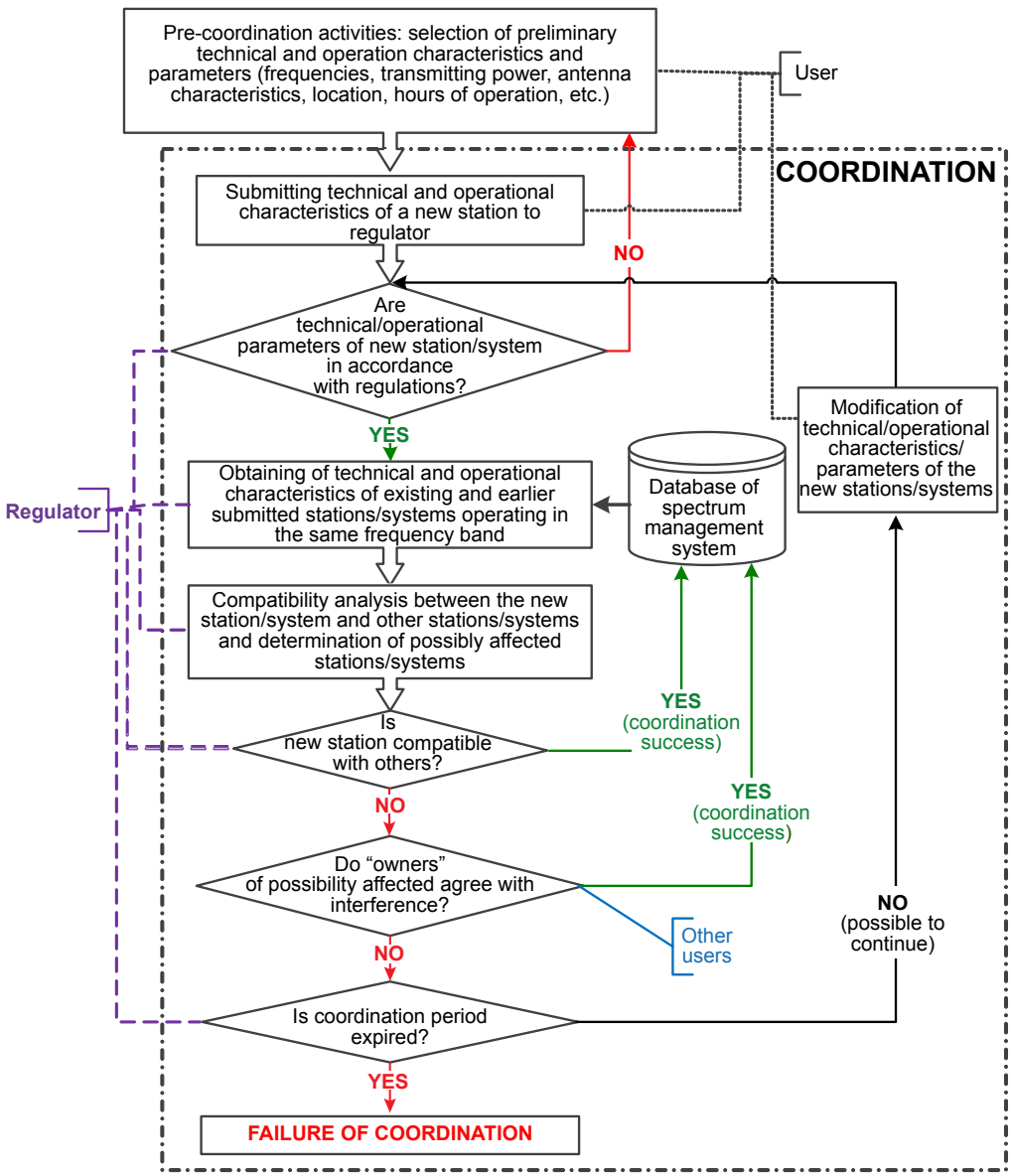
(a) Selected working frequencies of new station/system shall be allocated (on international and/or national level) to the radiocommunication service in which this new station/system should operate;

(b) Technical characteristics of the future station/system shall respect international and/or national regulatory limitations specified in the relevant regulations/rules (e.g. output power, antenna characteristics, out-of-band emission level), etc.

13. If technical/operational characteristics/parameters of a station/system are not accordance with international and/or national regulations/rules it is not possible to coordinate such a station/system.

14. A simplified general description of coordination process is provided in Figure 1.

Figure 1: Simplified description of radio-frequency assignment(s) coordination process



15. If the coordination process is completed successfully, then according to the Radio Regulations the frequency assignment(s) belonging to the new stations/systems obtain(s) rights to international recognition (RR No. **8.3**) and should be recorded into the Master International Frequency Register (MIFR):

(a) Any frequency assignment recorded in the Master Register with a favourable finding *(means successfully coordinated)* with respect to the Table of Frequency Allocations and other provisions of the RR shall have the right to international recognition;

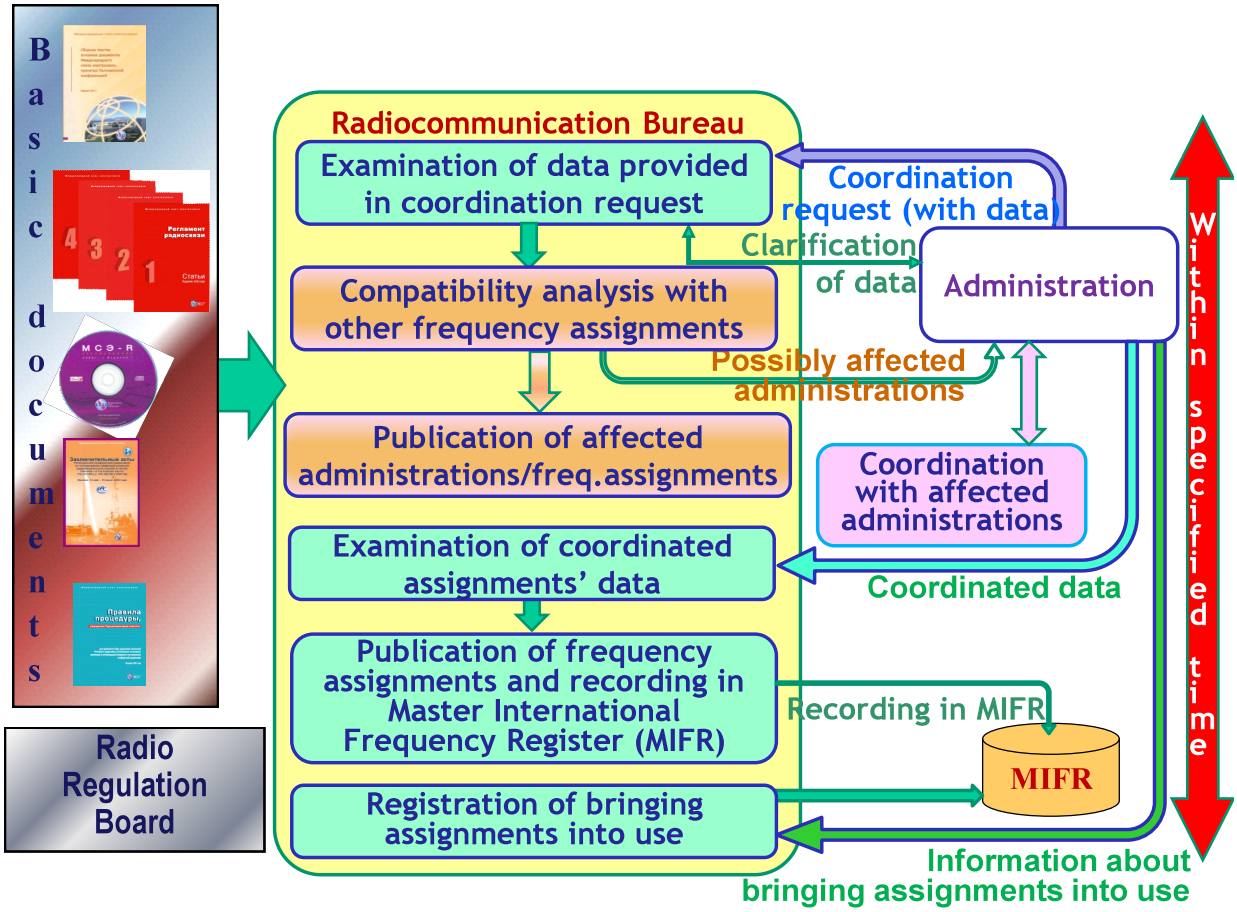
(b) This right means that other administrations shall take it into account when making their own assignments, in order to avoid harmful interference.

16. Similar or exactly the same rights are in general also applied according to national regulations, not only for internationally recognized assignments but also for assignments recorded in the national frequency register (or data base of the national spectrum management system).

17. Formally the coordination is completed after reaching agreement with all involved parties. However, it is extremely important to notify the coordinated frequency assignment(s) and their parameters to the relevant spectrum management authority (national and/or international) for recording them into the relevant database to be taken into account in the future.

18. The general description of the international coordination, notification and recording of frequency assignments through the Radiocommunication Bureau of the ITU is shown in Figure 2.

Figure 2: The general description of international coordination, notification and recording of frequency assignments



19. The time limit for satellite network coordination as specified in the Radio Regulation is seven years. It is a clear indication of complexity of the coordination process.

20. Descriptions of different elements of radio-frequency coordination process are provided in the following sub-sections of this section.

2.2 Radio services

21. Article **1** of the Radio Regulations contains definitions of over 40 different radio services most, but not all, of them are radiocommunication services. For example, the radio astronomy service is a radio service not a radiocommunication service.

22. Radio Regulations define a radiocommunication service as *"A service as defined in this Section involving the transmission, emission and/or reception of radio waves for specific telecommunication purposes"* (RR No. **1.19** in Section III–Radio services of Article 1).

23. Among these radio services there are four radiocommunication services of prime interest/concern for meteorology. The definition of those services and samples of applications operating are shown in the Table 1 below.

Table 1: List of the radio services that are of interest for meteorology and environmental observations

Provision numbers and definitions of radio services in the Radio Regulations (Edition of 2012)	Acronym	Sample(s) of applications[11]
RR No. 1.51 *Earth exploration-satellite service:* A *radiocommunication service* between *Earth stations* and one or more *space stations*, which may include links between *space stations*, in which: – information relating to the characteristics of the Earth and its natural phenomena, including data relating to the state of the environment, is obtained from *active sensors* or *passive sensors* on Earth *satellites*; – similar information is collected from airborne or Earth-based platforms; – such information may be distributed to *Earth stations* within the system concerned; – platform interrogation may be included. This service may also include *feeder links* necessary for its operation.	EESS	space-borne sensors (active and passive) for environmental monitoring the Earth's surface and atmosphere such as soil moisture, sea surface temperature, ice extend, snow cover, water vapour content and concentration in atmosphere, different gases content, altitude of the Earth's ocean, wind direction, wind speed and precipitation rate over the ocean surface, etc.
RR No. 1.50 *meteorological aids service:* A *radiocommunication service* used for meteorological, including hydrological, observations and exploration.	MetAids	radiosondes, dropsondes, rocketsonds for atmospheric in situ measurements with high vertical resolution (relative humidity, temperature and wind speed); lightning detection systems
RR No. 1.52 *meteorological-satellite service:* An *Earth exploration-satellite service* for meteorological purposes.	MetSat	meteorological satellite systems (geostationary and non-geostationary) for collection of data with visible and infrared images, passive and active sensors and disseminating these data

[11] See also Handbook "Use of radio spectrum for meteorology: weather, water and climate monitoring and prediction" at: www.itu.int/ITU-R/go/R-HDB-45-2008

Provision numbers and definitions of radio services in the Radio Regulations (Edition of 2012)	Acronym	Sample(s) of applications[11]
RR No. 1.48 *radiolocation service:* A *radiodetermination service* for the purpose of *radiolocation*. *Related definitions:* **RR No. 1.40** *radiodetermination service:* A *radiocommunication service* for the purpose of *radiodetermination*. **RR No. 1.9** *radiodetermination:* The determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to these parameters, by means of the propagation properties of *radio waves*.	RLS	meteorological radars: weather radars, wind-profiler radars for surface-based observations such as precipitation and wind measurements that also play crucial role in the immediate alert processes and disaster warning (flash flood or severe storm events, etc.)
RR No. 1.55 *space research service:* A *radiocommunication service* in which spacecraft or other objects in space are used for scientific or technological research purposes.	SRS	space weather observation system for monitoring the physical processes occurring in the space environment, driven by the Sun and Earth's upper atmosphere (the solar wind, flow of solar wind plasma which carries the Sun's embedded magnetic field and releases energy, such as flares of electromagnetic radiation (radio waves, IR, visible, UV, X-rays), energetic particles (electron, protons and heavy ions), and high speed plasma through coronal mass ejections, etc.)

24. It is also worth mentioning that the fixed-satellite service systems, through commercial payloads in the C-band (3 400–4 200 MHz) and the Ku Band (10 700–11 700 MHz), are used globally to disseminate weather, water and climate related information, including disaster warnings to meteorological agencies and user communities.

25. National spectrum management systems, in most cases, use the same classification of radio services as the ITU. However, it is necessary to check whether a national spectrum management system applies the same classification or if there is a difference at least for some services.

2.3 Frequency allocations and the Table of Frequency Allocations

26. *Allocation* (of a frequency band): Entry in the Table of Frequency Allocations of a given frequency band for the purpose of its use by one or more terrestrial or space *radiocommunication services* or the *radio astronomy service* under specified conditions. This term shall also be applied to the frequency band concerned (RR No. **1.16**).

27. An allocation of portion of radio-frequency spectrum could be made to one or several radiocommunication services.

28. It could have different rights and obligations:

(a) *Primary allocations* grant to specific services priority in using the allocated spectrum. When there are multiple primary services within a frequency band, they all have equal rights. A station, however, has the right to be protected from any others that start operation at a later date;

(b) *Secondary allocations* are made for services that must protect all primary allocations in the same band. Services operating in secondary allocations must not cause harmful interference to, and must accept interference from, primary service stations. All secondary service stations have equal rights among themselves in the same frequency band.

29. An allocation usually does not combine together services that use high and lower power systems (such as terrestrial broadcasting stations and meteorological aids stations, for example, radiosondes).

30. Tables of frequency allocations to different radio services and technical/operational limitations rights, obligations and responsibilities of users/operators and regulators, etc. are normally incorporated in the national and international regulations and/or rules.

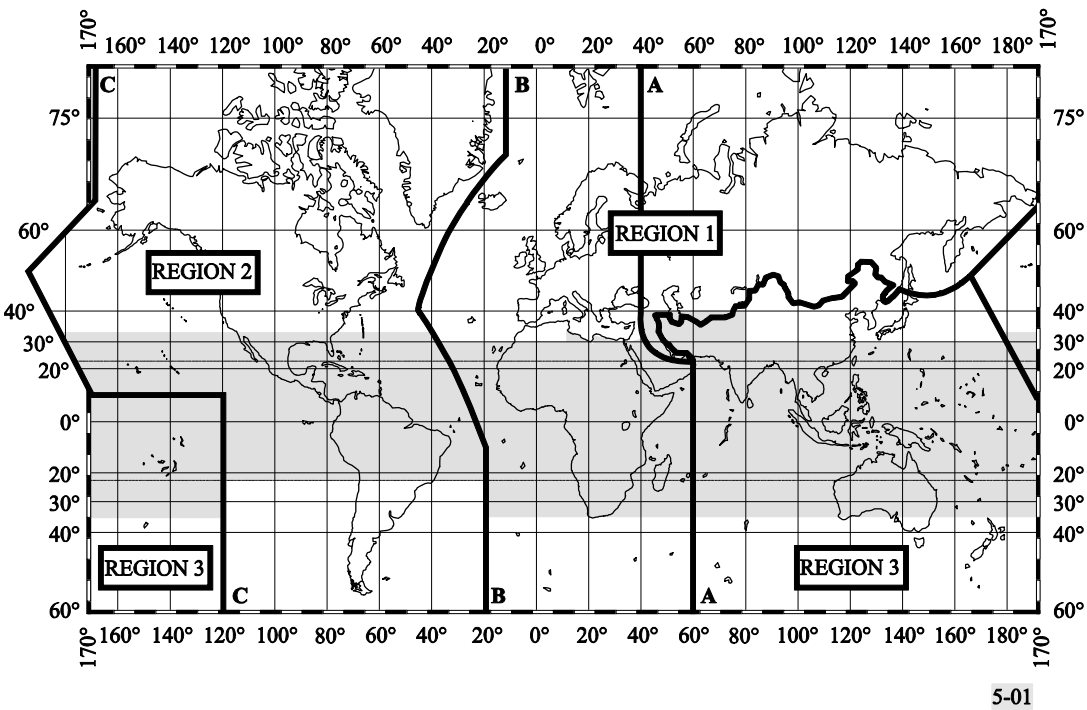
31. The Radio Regulations contain the international Table of Frequency Allocations (included in RR Article **5**), which is based on a block allocation method with footnotes. The regulated frequency band (8.3 kHz–3 000 GHz) is segmented into smaller bands and allocated to over 40 defined radio services. Allocations to the radio services made either on PRIMARY or secondary basis (the latter shall cause no harmful interference to, nor claim protection from, the former). Footnotes are used to further specify how the frequency ranges are to be assigned or used.

2.4 ITU Regions

32. For the allocation of frequencies the world has been divided into three Regions as shown on the Figure 3 below. Descriptions of ITU Regions are provided in RR Nos. **5.3**, **5.4** and **5.5**.

> **5.3** *Region 1:* Region 1 includes the area limited on the east by line A (lines A, B and C are defined in Figure 3 below) and on the west by line B, excluding any of the territory of the Islamic Republic of Iran which lies between these limits. It also includes the whole of the territory of Armenia, Azerbaijan, the Russian Federation, Georgia, Kazakhstan, Mongolia, Uzbekistan, Kyrgyzstan, Tajikistan, Turkmenistan, Turkey and Ukraine and the area to the north of Russian Federation which lies between lines A and C.
>
> **5.4** *Region 2:* Region 2 includes the area limited on the east by line B and on the west by line C.
>
> **5.5** *Region 3:* Region 3 includes the area limited on the east by line C and on the west by line A, except any of the territory of Armenia, Azerbaijan, the Russian Federation, Georgia, Kazakhstan, Mongolia, Uzbekistan, Kyrgyzstan, Tajikistan, Turkmenistan, Turkey and Ukraine and the area to the north of the Russian Federation. It also includes that part of the territory of the Islamic Republic of Iran lying outside of those limits.

Figure 3: ITU Radiocommunication Regions



33. An extract from the RR Article **5** Table of Frequency Allocation is shown in Table 2. Capital letters indicate PRIMARY allocations, lower case is used to indicate secondary allocations. Numbers are used for provisions employed for specifying conditions, additional and alternative allocations and descriptions of special uses. For example RR No. **5.341**:

> **5.341** In the bands 1 400–1 727 MHz, 101–120 GHz and 197–220 GHz, passive research is being conducted by some countries in a programme for the search for intentional emissions of extra-terrestrial origin.

34. Each column of the Table of Frequency Allocations corresponds to one of the Regions. Where an allocation occupies the whole width of the Table of one or two of three columns, this is a worldwide allocation or a Regional allocation, respectively – see the Table 2 below.

Table 2: An Extract from the RR Article 5 Table of Frequency Allocations

<table>
<tr><th colspan="3">Allocation to services</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td>1 670-1 675</td><td colspan="2">METEOROLOGICAL AIDS
FIXED
METEOROLOGICAL-SATELLITE (space-to-Earth)
MOBILE
MOBILE-SATELLITE (Earth-to-space) 5.351A 5.379B
5.341 5.379D 5.379E 5.380A</td></tr>
<tr><td>1 675-1 690</td><td colspan="2">METEOROLOGICAL AIDS
FIXED
METEOROLOGICAL-SATELLITE (space-to-Earth)
MOBILE except aeronautical mobile
5.341</td></tr>
<tr><td>1 690-1 700
METEOROLOGICAL AIDS
METEOROLOGICAL-SATELLITE (space-to-Earth)
Fixed
Mobile except aeronautical mobile
5.289 5.341 5.382</td><td colspan="2">1 690-1 700
METEOROLOGICAL AIDS
METEOROLOGICAL-SATELLITE (space-to-Earth)
5.289 5.341 5.381</td></tr>
<tr><td colspan="2">1 700-1 710
FIXED
METEOROLOGICAL-SATELLITE (space-to-Earth)
MOBILE except aeronautical mobile</td><td>1 700-1 710
FIXED
METEOROLOGICAL-SATELLITE (space-to-Earth)
MOBILE except aeronautical mobile</td></tr>
<tr><td colspan="2">5.289 5.341</td><td>5.289 5.341 5.384</td></tr>
</table>

35. As ITU Regions may have different allocations, sometimes done by footnote to the Table, it is also necessary to, apart from checking the table itself, to check provisions included in each row, because sometimes they contain additional allocations. For example, the 15.4–18.4 GHz part of the Table of Frequency allocations (see Table 3) does not contain allocations to the meteorological satellite service, but **RR No. 5.519** at the bottom 17.7–18.1 GHz row in the Region 2 column and 18.1–18.4 GHz row in the global column provides additional allocation to the MetSat for geostationary satellites as follows:

> **5.519** *Additional allocation:* the bands 18–18.3 GHz in Region 2 and 18.1–18.4 GHz in Regions 1 and 3 are also allocated to the meteorological-satellite service (space-to-Earth) on a primary basis. Their use is limited to geostationary satellites. (WRC-07)

Table 3: A fragment of the 15.4-18.4 GHz portion of the Table of Frequency Allocations in Article 5 of the Radio Regulations 15.4-18.4 GHz

<table>
<tr><th colspan="3">Allocation to services</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td colspan="3">…</td></tr>
<tr><td>17.3-17.7
FIXED-SATELLITE
(Earth-to-space) 5.516
(space-to-Earth) 5.516A 5.516B
Radiolocation
5.514</td><td>17.3-17.7
FIXED-SATELLITE
(Earth-to-space) 5.516
BROADCASTING-SATELLITE
Radiolocation
5.514 5.515</td><td>17.3-17.7
FIXED-SATELLITE
(Earth-to-space) 5.516
Radiolocation
5.514</td></tr>
<tr><td rowspan="2">17.7-18.1
FIXED
FIXED-SATELLITE
(space-to-Earth) 5.484A
(Earth-to-space) 5.516
MOBILE</td><td>17.7-17.8
FIXED
FIXED-SATELLITE
(space-to-Earth) 5.517
(Earth-to-space) 5.516
BROADCASTING-SATELLITE
Mobile
5.515</td><td rowspan="2">17.7-18.1
FIXED
FIXED-SATELLITE
(space-to-Earth) 5.484A
(Earth-to-space) 5.516
MOBILE</td></tr>
<tr><td>17.8-18.1
FIXED
FIXED-SATELLITE
(space-to-Earth) 5.484A
(Earth-to-space) 5.516
MOBILE
5.519</td></tr>
<tr><td>18.1-18.4</td><td colspan="2">FIXED
FIXED-SATELLITE (space-to-Earth) 5.484A 5.516B
(Earth-to-space) 5.520
MOBILE
5.519 5.521</td></tr>
</table>

2.5 Regional telecommunication organizations

36. ITU Member States have established six regional telecommunication organizations that formally are not part of the regulatory development process, but play a significant role in world and regional preparation for world radiocommunication conferences. These regional telecommunication organizations coordinate and develop common proposals related to different aspects of spectrum management including proposals on worldwide and regional allocations for consideration at WRC. The organizations are the:

(a) African Telecommunication Union (ATU);

(b) Arab Spectrum Management Group (ASMG);

(c) Asia-Pacific Telecommunity (APT);

(d) European Conference of Postal and Telecommunication Administrations (CEPT);

(e) Inter-American Telecommunication Commission (CITEL); and

(f) Regional Commonwealth in the Field of Communications (RCC).

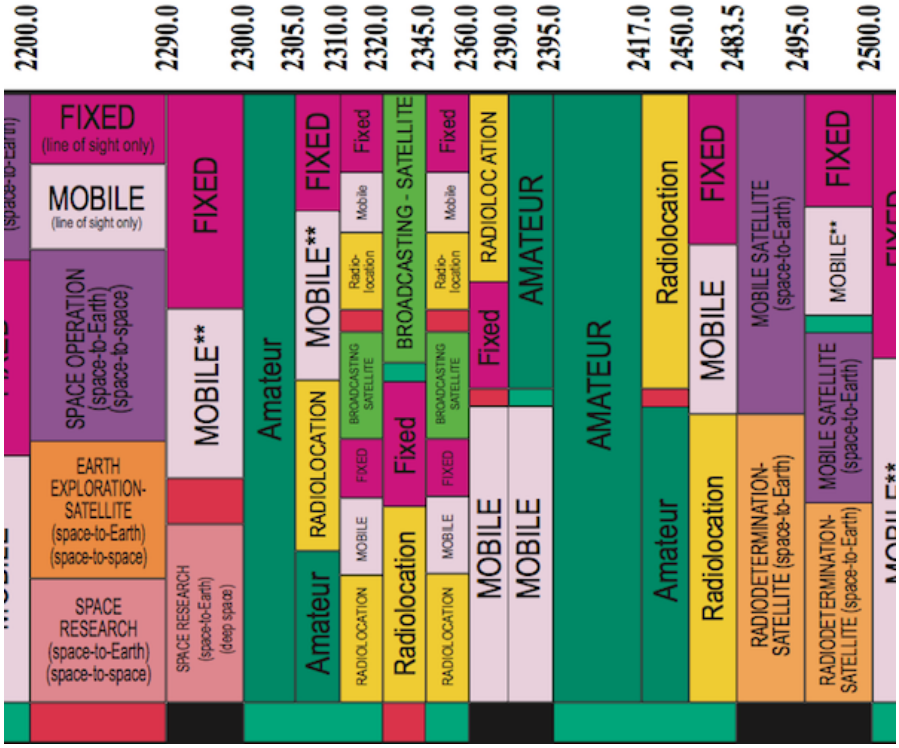
37. ITU Member States have voting rights in the WRCs, but these regional organizations have no such rights. Nevertheless they carry a lot of weight in the decision-making process. It is essential that national and regional bodies are fully aware of the impact of decisions on Earth observations and other WMO activities.

2.6 National frequency allocations

38. Although most countries follow in the great degree the ITU allocations, it is still possible for a country to deviate from the international allocations, to a limited degree, to satisfy specific national requirements. That is why many regulators develop national frequency allocation tables.

39. National frequency allocation tables (sometimes called plans or otherwise) are usually published on web pages of national regulators – see sub-section 2.10 [international and national regulators]. Some of them provide national frequency allocation tables in more transparent and clear way using a graphical format[12]. A fragment of such graphical presentation is shown in Figure 4 below as an example.

Figure 4: An extract from a frequency allocation table for the frequency range 2 200–2 500 MHz



2.7 Technical/operational limitations

40. Frequencies are assigned and used with due account of any restrictions on their use, stipulated by the international and national regulations. Some countries may place local limitations on the use of specified frequency bands for individual radio services. These can be restrictions on the utilization of some frequencies by particular users, on the radiated power in specific radio services operating in a specified frequency band, or in certain geographical areas.

2.8 Technical and/or operational conditions and limitations contained in the international and national agreements, law, regulations and rules

41. The following documents of the International Telecommunication Union are to be used when an assignment needs international recognition:

(a) The ITU Radio Regulations (mainly Article **5**, Article **21** – for assignments belonging to the terrestrial services, Article **22** – for assignments belonging to the space services). RR

[12] See an example at: www.acma.gov.au/webwr/radcomm/frequency_planning/spectrum_plan/arsp-wc.pdf, www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/2014_Canadian_Radio_Spectrum_Chart.pdf/$file/2014_Canadian_Radio_Spectrum_Chart.pdf, www.fab.gov.pk/images/spectrumchart.jpg, www.icta.mu//images/spectrum.jpg.

contain the complete texts as adopted by the World Radiocommunication Conference (Geneva, 1995) (WRC-95) and subsequently revised and adopted by World Radiocommunication Conferences, including all Appendices, Resolutions, Recommendations and ITU-R Recommendations incorporated by reference; available free of charge at: http://www.itu.int/en/publications/ITU-R/pages/publications.aspx?parent=R-REG-RR-2012&media=electronic;

(b) The Rules of Procedure, approved by the Radio Regulations Board, for the application by the Radiocommunication Bureau of the provisions of the Radio Regulations, Regional Agreements and Resolutions and Recommendations of World and Regional Radiocommunication Conferences; available free of charge at: https://www.itu.int/en/publications/ITU-R/pages/publications.aspx?parent=R-REG-ROP-2012&media=electronic;

– Recommendations of the ITU Radiocommunication Sector; available free of charge at: http://www.itu.int/pub/R-REC.

42. RR Article **5** contains some provisions specifying conditions of the use for some stations/systems. Two samples (RR Nos. **5.54A** and **5.549A**) are shown below.

> **5.54A** Use of the 8.3–11.3 kHz frequency band by stations in the meteorological aids service is limited to passive use only. In the band 9–11.3 kHz, meteorological aids stations shall not claim protection from stations of the radionavigation service submitted for notification to the Bureau prior to 1 January 2013. For sharing between stations of the meteorological aids service and stations in the radionavigation service submitted for notification after this date, the most recent version of Recommendation ITU-R RS.1881 should be applied. (WRC-12)

> **5.549A** In the band 35.5–36.0 GHz, the mean power flux-density at the Earth's surface, generated by any spaceborne sensor in the Earth exploration-satellite service (active) or space research service (active), for any angle greater than 0.8° from the beam centre shall not exceed –73.3 dB(W/m^2) in this band. (WRC-03)

43. Similarly RR Articles 21 and 22 contain technical limitations applied to stations of different space services including those of the interest for the meteorological community. Two samples are provided below.

> **22.4**§ 3 In the frequency band 29.95–30 GHz space stations in the Earth exploration-satellite service on board geostationary satellites and operating with space stations in the same service on board non-geostationary satellites shall have the following restriction:
>
> Whenever the emissions from the geostationary satellites are directed towards the geostationary-satellite orbit and cause unacceptable interference to any geostationary-satellite space system in the fixed-satellite service, these emissions shall be reduced to a level at or less than accepted interference.

> **22.5**§ 4 In the frequency band 8 025–8 400 MHz, which the Earth exploration-satellite service using non-geostationary satellites shares with the fixed-satellite service (Earth-to-space) or the meteorological-satellite service (Earth-to-space), the maximum power flux-density produced at the geostationary-satellite orbit by any Earth exploration-satellite service space station shall not exceed –174 dB(W/m^2) in any 4 kHz band.

44. National operational and technical conditions/limitations on the use certain frequency bands by stations/systems/applications belonging to the specific services in different frequency bands are described in national regulations/rules that are usually published on web-pages of national regulators – see sub-section 2.10 [International and national regulators].

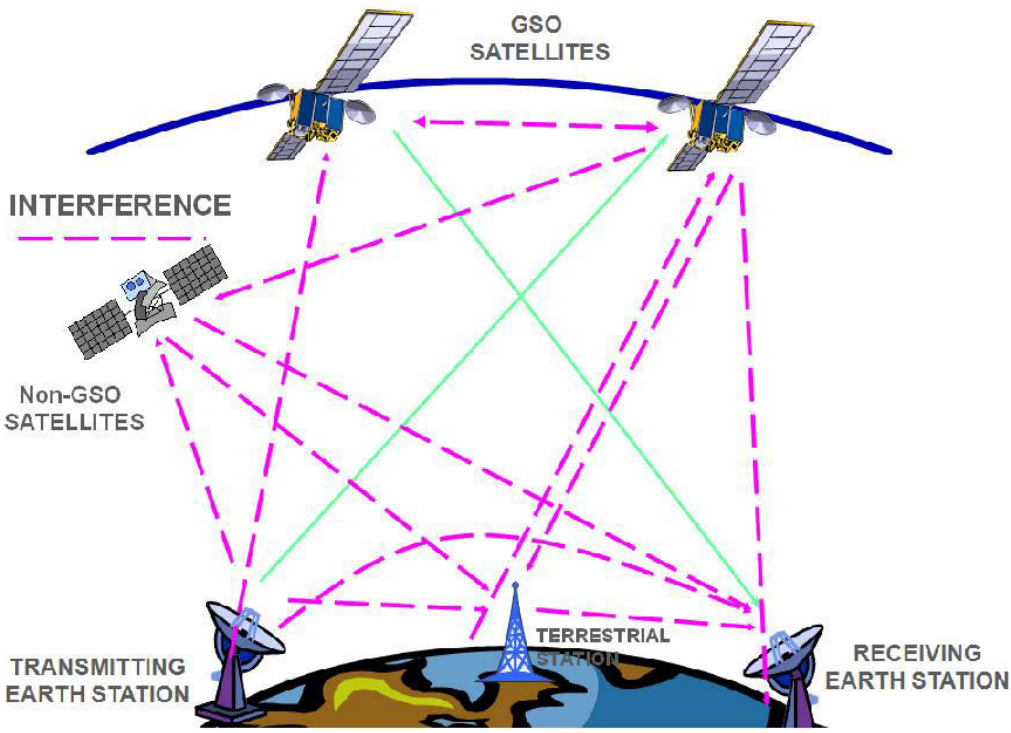
2.9 Analysis of electromagnetic compatibility between existing and newly submitted stations/systems

45. The analysis of electromagnetic compatibility of stations/systems using the same frequency band and the analysis of interfering effects of out-of-band emissions spilling in the adjacent bands is a very complicated engineering task. Such analysis requires sophisticated software and significant computing resources. Fortunately, ITU-R processes identify and agree on standard methods so different projects can arrive at consistent solutions. As such, methods, criteria and algorithms to be employed for electromagnetic compatibility analysis between station/systems belonging to different radio services on international level are specified in Appendix 5 of the RR titled “Identification of administrations with which coordination is to be effected or agreement sought under the provisions of Article 9”.

46. The national approaches, methods and algorithms to electromagnetic compatibility analysis applicable on the national level are usually provided in the relevant national regulations/rules published on the “regulator web-page” – see sub-section 2.10 [International and national regulators].

47. The complexity of the problem is reflected in Figure 5 for a new geostationary satellite.

Figure 5: An illustration of types of interfering sources to be considered during electromagnetic compatibility analysis of a new geostationary satellite system



48. Another important factor is the amount of frequency assignments to be considered in compatibility analysis. The ITU Master International Frequency Register, the database of radio stations operating around the world, is constantly updated by the ITU Radiocommunication Bureau. It contains more than 2 million frequency assignments for terrestrial services and more than 1.1 million assignments to space services. The Radiocommunication Bureau treats every year 120 plus thousands of notices for stations of terrestrial services and about 1300 filings of satellite networks, covering some 0.5 million frequency assignments and 300 Earth stations and radio-astronomy stations.

2.10 International and national regulators

49. The global management of the radio-frequency spectrum and satellite orbits is provided by the International Telecommunication Union (ITU) established in 1865. The ITU is a **specialized agency of the United Nations for telecommunications and information and communication technologies (ICTs).**

50. According to Article 1 of the ITU Constitution (see at: http://www.itu.int/net/about/basic-texts/constitution/chapterii.aspx)[13] "the ITU shall in particular:

11 PP-98 *a)* effect allocation of bands of the radio-frequency spectrum, the allotment of radio-frequencies and the registration of radio-frequency assignments and, for space services, of any associated orbital position in the geostationary-satellite orbit or of any associated characteristics of satellites in other orbits, in order to avoid harmful interference between radio stations of different countries;

12 PP-98 *b)* coordinate efforts to eliminate harmful interference between radio stations of different countries and to improve the use made of the radio-frequency spectrum for radiocommunication services and of the geostationary-satellite and other satellite orbits;"

51. The ITU Radiocommunication Sector (ITU-R) is the international steward of the radio-frequency spectrum and satellite orbits. ITU-R through the World Radiocommunication Conferences (WRCs) allocates the necessary radio-frequency spectrum to allow the effective operation of different radio-based systems and applications (terrestrial and space) used for different purposes including climate monitoring and prediction, weather forecasting and disaster early warning and detection. ITU-R also carries out studies and approves international standards on radiocommunication matters (ITU-R Recommendations in the ITU terminology).

Figure 6: Radio Regulations – 4 volumes ~2000 pages.

52. It works through world and regional Radiocommunication conferences, the Radio Regulation Board (RRB), Radiocommunication Assemblies (RA), Radiocommunication Study Groups and the Radiocommunication Bureau (BR). BR implements coordination and recording procedures for space and terrestrial wireless systems, networks and stations.

53. The WRCs revise usually every 3-4 years the texts of the Radio Regulations (see Figure 6), international treaty, covering and regulating the use of the radio-frequency spectrum and satellite orbits by systems and stations of radio services. The main goal of the RR is to ensure that reliable radio services are available everywhere and at every moment, enabling people to live and travel safely and enjoy high performance radiocommunications. For further relations between the ITU and the WMO activities see "WMO Strategy on Radio-Frequency Protection for Meteorology" at: http://wis.wmo.int/file=1029.

54. The ability of each country to take full advantage of the spectrum resource depends heavily on spectrum management activities that facilitate the implementation of radio systems and ensure minimum interference. National spectrum management consists of the structures, procedures, and regulations whereby an administration controls the use of the radio spectrum within its geographical boundaries. Effective management of the spectrum resource encompasses major directives that establish the responsibility of the national authority. This authority regulates the spectrum use as well as all related processes. Although no two administrations would manage the

[13] Collection of the basic texts of the International Telecommunication Union, including the ITU Constitution, Convention ant other texts, is available free of charge at: http://www.itu.int/pub/S-CONF-PLEN-2011.

spectrum in exactly the same manner, the basic processes are essential to all national approaches.

55. Usually the national radiocommunication law delegates the authority and responsibility to manage spectrum use to one or more government bodies. Many countries establish their national frequency coordination procedures. Frequency coordination is the process of obtaining agreement between existing spectrum users and a prospective spectrum user when there is some potential spectrum conflict. Coordination on the national level may involve technical, administrative, legal, or other considerations. Frequency coordination at the national level is essential because the same frequency band is, typically, shared by radio systems that belong to different users. For example, some microwave links may be operated by different governmental agencies, others by national or local carriers, and some by one or more private companies – all using the same frequency allocations. The process of coordination is regulated by appropriate national rules. All users potentially affected by a new radio system under consideration are obliged to examine the possibility of interference with that assignment.

56. How to find what ministry/organization/commission is in charge of the spectrum regulations? It is possible to do so through the ITU Global Directory published and maintained at: http://www.itu.int/en/membership/Pages/default.aspx. The Global Directory contains the basic information on ITU membership, including information concerning national regulators. Clicking on the ITU Member States entry under **Lists of the Global Directory** results in the list of the ITU Member States as shown on the Figure 7 below.

Figure 7: An extract from the list of the ITU Member States

ITU Global Directory

TIES Main Page | FAQ | Email | GD Map Sun Jun 22 09:41:53 CEST 2014

Search the ITU Global Directory

[ITU Member States] display totals? map?

Designation in English	Administrative Region [?]	Ctry Symbol	Domain Name	Date of Entry
Afghanistan	E	AFG	.af	1928/04/12
Albania (Republic of)	C	ALB	.al	1922/06/02
Algeria (People's Democratic Republic of)	D	ALG	.dz	1963/05/03
Andorra (Principality of)	B	AND	.ad	1993/11/12
Angola (Republic of)	D	AGL	.ao	1976/10/13
Antigua and Barbuda	A	ATG	.ag	1987/02/04
Argentine Republic	A	ARG	.ar	1889/01/01
Armenia (Republic of)	C	ARM	.am	1992/06/30
Australia	E	AUS	.au	1878/05/27
Austria	B	AUT	.at	1866/01/01
Azerbaijan (Republic of)	C	AZE	.az	1992/04/10
Bahamas (Commonwealth of the)	A	BAH	.bs	1974/08/19
Bahrain (Kingdom of)	E	BHR	.bh	1975/01/01
Bangladesh (People's Republic of)	E	BGD	.bd	1973/09/05
Barbados	A	BRB	.bb	1967/08/16
Belarus (Republic of)	C	BLR	.by	1947/05/07
Belgium	B	BEL	.be	1866/01/01

57. Then it is necessary to click on the country of interest. Let's click on Bangladesh (People's Republic of). The next screen will present the detailed administrative information related to this member state, including information about the regulation authorities, as shown in Figure 8 below.

Figure 8: A part of administrative information concerning an ITU Member State – the People's Republic of Bangladesh

Name	ITU-R	ITU-T	ITU-D	Categories (?)
Bangladesh - Bangladesh - Bangladesh				
Ministry of Posts, Telecommunications and Information Technology , Government of the People's Republic of Bangladesh , DHAKA	**MINISTRY**			
Bangladesh Telecommunication Regulatory Commission (BTRC) , IEB Bhaban , DHAKA	**ADMIN / REGULATOR**			
National Broadcasting Authority , Directorate General , DHAKA	ADMIN RELATED			
Banglalink Digital Communications Ltd. , DHAKA			X	ROA
Grameenphone (GP) Limited , DHAKA			X	ROA
Robi Axiata Limited , DHAKA			ASSOCIATE SG1	ROA
***6 member(s) (ITU-R=0, ITU-T=0, ITU-D=2, any=2); Associates: ITU-R=0, ITU-T=0, ITU-D=1, any=1).				

58. Going further and clicking on the name of in the row containing the REGULATOR indicator (see above) it is possible to get necessary information concerning the relevant national regulator (address, phones and URL) as presented in Figure 9.

Figure 9: Information concerning the regulation authority of the People's Republic of Bangladesh

Address details:

Category: ADMIN / REGULATOR

Bangladesh Telecommunication Regulatory Commission (BTRC)
IEB Bhaban
Ramna
DHAKA 1000
Bangladesh

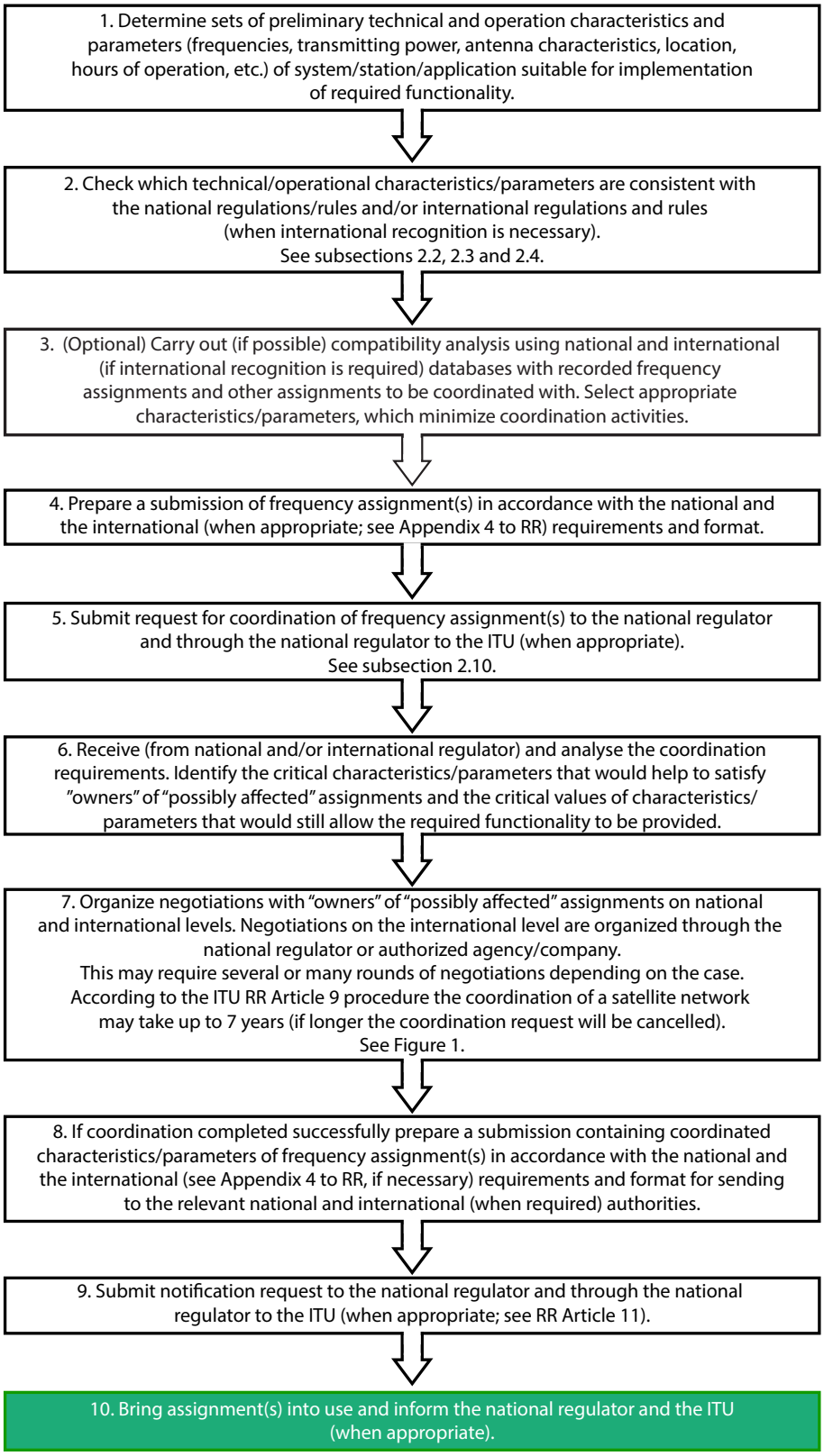
Tf	+880 2 7162277
Tf	+880 2 9558855
Fax	+880 2 9556677
URL	www.btrc.gov.bd

TIES: TIES FocalPoint + TIES users

3. STEP-BY-STEP COORDINATION GUIDELINE

59. The step-by-step guideline of coordination of radio-frequencies within ITU is shown in Figure 10. How an NMHS should get engaged in this process is described in Section 4 below. Formally speaking, steps 8 to 10 of Figure 10 are not part of the coordination process; however, they are essential for protection of the coordinated assignment(s) (system/station/application) from harmful interference of future systems/stations/applications.

Figure 10: Step-by-step guideline of coordination of radio frequencies within ITU



4. HOW TO ENGAGE AN NMHS IN ITU'S FREQUENCY MANAGEMENT AND COORDINATION

60. The purpose of this Guide is primarily to assist the heads of NMHSs to understand the ITU process that supports radio-frequency coordination, and what they should do to engage in their national, regional and global coordination. The following summarizes some common elements of approaches that Members have found to be successful.

61. In order to engage in radio-frequency coordination, there are two high-level objectives. The main objective is to be effective in influencing frequency management decision makers. The second high-level objective is to use the wider WMO expertise to ensure frequency regulators decisions relative to the meteorological requirements are scientifically and technically strong. The nature of radio-frequency coordination activities means that input needs to be provided at national, regional and global forums.

62. An effective approach used by some NMHSs in achieving the first objective has been to identify which agencies or departments are the frequency regulators and to convince the regulatory body and its parent ministry of the importance of meteorology to national priorities. This opens the way to emphasize meteorology's dependence on frequencies. Having ministers, or at least departmental head, buy in is an important element that will ensure a sustainable relationship. Once achieved, the aim is then to get involved in the national, regional and global processes, including NMHS representation on relevant delegations.

63. Annex 1 describes the above in more detail and identifies some tools to assist in achieving these objectives. It is noted that the CBS Steering Group on Radio-frequency Coordination (SG-RFC), regional association relevant infrastructure working groups and the Secretariat are important sources of support for your activities. As such, NMHSs are encouraged to participate through registering their national focal point or experts in SG-RFC or regional groups, and to encourage them to actively participate.

5. CONCLUSION

64. The purpose of this Guide is primarily to assist the heads of NMHSs to understand the ITU process that supports radio-frequency coordination, and what they should do to engage in their national, regional and global coordination.

65. Coordination of frequency assignments of terrestrial and space radiocommunication systems, stations and applications belonging to terrestrial and space radio services is one of the most important methods providing the way for the effective operations all radio systems and optimal use of radio-frequency spectrum and satellite orbits.

66. Coordination of a system/station/application in many cases is not only mandatory in accordance national and international regulations and rules but also necessary for obtaining national/international recognition and as the result protection from harmful interference from frequency assignments of the existing and future stations/systems that will support successful operation of this system/station/application in particular and the WMO Integrated Global Observing System (see Figure 11) in general.

Figure 11: WMO Integrated Global Observing System

67. It becomes especially essential taking into account the limited financial resources available for the National Meteorological and Hydrological Services, regional and national organizations involved in meteorological activities as well as for the World Meteorological Organization that cannot afford improper implementation of national regulations, regional and international agreements concerning the use of radio-frequency spectrum and satellite orbits.

ANNEX 1 – POSSIBLE ACTION PLAN

High Level Objectives	Approach	Tools
(1) Influence Decision Making		
(a) Get Ministerial / Departmental Head support from: (i) NMHS parent body (ii) Regulatory Department and its parent body. (b) To get involved in regulatory processes (i) National (ii) Regional (iii) ITU-R / WRC bodies	(i) Use available guidance to brief relevant minister and department on the importance of RF to meteorological and related services (ii) Identify national priorities (e.g. Emergency response and disaster risk reduction) and define their dependence on NMHS services (iii) Identify frequency regulator and arrange meetings between departmental heads. (iv) Get NMHS representative on regulatory agency's frequency management steering committee or its equivalent (ie Board Level participation). (v) Aim to get NMHS technical expert on national delegations to relevant ITU-R regional and global meetings.	• Guide to NMHS on spectrum management • Handbook on the "Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction" • Government policy documents defining national priorities • ITU-R list of regulatory agencies[14] • SG-RFC/ WMO Secretariat for identifying – relevant regional groups – relevant ITU working groups and committees. • SG-RFC membership and TORs.
(2) Ensure sound scientific and technical input to frequency management.		
(a) Get involved in WMO RFC activity (i) National (ii) Regional (iii) Global	(i) National Identify a national focal point on radiofrequency matters. Most likely from your observations or engineering staff. (ii) Regional 1. At a minimum, register Focal Point and relevant experts with Regional WIGOS/Infrastructure working group 2. Support focal point/expert's participation in regional WIGOS radio-frequency coordination activities. (iii) Global 1. Register your focal point and experts as associated members of SG-RFC 2. Support participation of NMHS representative in national delegations to SG-RFC and relevant ITU-R /WRC related meetings.	• Report on regional association sessions and subsequent TORs of working groups and bodies. • SG-RFC/ WMO Secretariat for identifying relevant: – regional groups – ITU working groups and committees • SG-RFC membership and TORs • ITU-R list of meetings and registration pages

[14] ITU Global Directory published and maintained at: http://www.itu.int/en/membership/Pages/default.aspx

Recommendation 14 (CBS-Ext.(2014))

PREPARATION FOR NEW SATELLITE SYSTEMS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) That the transition to the operation of new satellite systems enables significant enhancements of products and services delivered by Members,

(2) That the implementation of such new satellite systems in operational schemes has a major impact on user infrastructure, systems, applications and services, and generally requires coordinated actions at the scientific, technical, financial, organizational and educational levels,

(3) That timely and careful preparation is essential to avoid any disruption of operations upon transition to a new system, and to take advantage of the new capabilities as early as possible to provide a better service to the users,

Noting further:

(1) That new generation geostationary systems are being implemented or planned to be implemented in the 2015–2020 time frame by Japan, China, the United States of America, the Republic of Korea, the Russian Federation and the European Organization for the Exploitation of Meteorological Satellites,

(2) That other new generation systems are being developed for implementation in polar orbit and other orbit types in the coming decade,

Recalling:

(1) The Commission for Basic Systems Guidelines for Ensuring User Readiness for New Generation Satellites adopted at its fifteenth session,

(2) The Satellite User Readiness Navigator (SATURN) implemented by the Secretariat, which is a portal providing a unique entry point to updated technical information from satellite operators related to the new systems,

(3) The Observing Systems Capability Analysis and Review Tool (OSCAR), which is part of the WIGOS Operational Information Resource and contains comprehensive information on space-based systems of relevance to WMO activities,

(4) Resolution 12 (EC-65) – Regional requirements for satellite data access and exchange,

Strongly recommends to all Members concerned to set up user preparation projects in advance of the launches of new satellite systems, in accordance with the Commission for Basic Systems Guidelines for Ensuring User Readiness for New Generation Satellites;

Urges satellite operators to provide regular and timely updates on their new systems through appropriate means and in particular through inputs to SATURN and OSCAR;

Requests the Expert Team on Satellite Systems and the Inter-Programme Expert Team on Satellite Utilization and Products, the regional associations, through their appropriate expert groups on satellite data access and exchange, the Consultative Meetings on High-level Policy on Satellite Matters, and the Secretariat to take appropriate actions in collaboration with satellite operators to raise awareness among Members and to facilitate a seamless transition to new satellite systems;

Requests the Secretary-General to communicate the present recommendation to all Members and submit it for consideration by the Seventeenth World Meteorological Congress.

Recommendation 15 (CBS-Ext.(2014))

PROCEDURES FOR MAINTAINING MANUALS AND GUIDES MANAGED BY THE COMMISSION FOR BASIC SYSTEMS

THE COMMISSION FOR BASIC SYSTEMS,

Noting the effectiveness of the procedures introduced by the Commission at its fourteenth session for maintaining the Technical Regulations associated with the Table Driven Code Forms that are contained in the *Manual on Codes* (WMO-No. 306),

Noting further:

(1) That the same procedures have been applied to maintaining the WMO Core Profile of the ISO 19115 metadata standard in the *Manual on the WMO Information System* (WMO-No. 1060),

(2) That other Technical Regulations maintained by the Commission would benefit from using the approach used for maintaining the *Manual on Codes*,

Recommends:

(1) That the procedure, as given in Annex 1 to the present recommendation, be applied to the *Manual on the Global Observing System* (WMO-No. 544), the *Guide to the Global Observing System* (WMO-No. 488), the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), the *Guide to Public Weather Services Practices* (WMO-No. 834), the *Manual on Codes*, the *Manual on the Global Telecommunication System* (WMO-No. 386) and the *Manual on the WMO Information System*, and to the technical guides that support them with effect from 1 July 2015;

(2) That the text of Annex 1 to the present recommendation be inserted in the *Technical Regulations* (WMO-No 49), Volume I as Appendix F, and be referenced in the introductions of the *Manual on the Global Observing System*, the *Guide to the Global Observing System*, the *Manual on the Global Data-processing and Forecasting System*, the *Guide to Public Weather Services Practices*, the *Manual on Codes*, the *Manual on the Global Telecommunication System* and the *Manual on the WMO Information System*;

(3) That references to existing procedures be removed, as given in Annex 2 to the present recommendation;

(4) That paragraph 15 of the General Provisions of the *Technical Regulations,* Volume I be amended, as given in Annex 3 to the present recommendation;

Requests the Secretary-General to make the amendments to the *Technical Regulations* and the Manuals and Guides, as given in Annexes 1 and 2 to the present recommendation;

Authorizes the Secretary-General to make any consequent purely editorial changes to the Manuals or Guides referenced in the present recommendation.

Annex 1 to Recommendation 15 (CBS-Ext.(2014))

MANAGING CHANGES TO WMO MANUALS AND GUIDES THAT ARE THE RESPONSIBILITY OF THE COMMISSION FOR BASIC SYSTEMS

1. PROCEDURES FOR AMENDING WMO MANUALS THAT ARE THE RESPONSIBILITY OF THE COMMISSION FOR BASIC SYSTEMS

1.1 Designation of responsible committees

The Commission for Basic Systems (CBS) shall, for each Manual and Guide, designate one of its Open Programme Area Groups (OPAGs) as being responsible for that Manual and its associated technical guides. The Open Area Programme Group may choose to designate one of its Expert Teams as the designated committee for managing changes to all or part of that Manual; if no Expert Team is designated, the Implementation Coordination Team for the OPAG takes on the role of the designated committee.

1.2 General validation and implementation procedures

1.2.1 Proposal of amendments

Amendments to a Manual or a Guide managed by the Commission for Basic Systems (CBS) shall be proposed in writing to the WMO Secretariat. The proposal shall specify the needs, purposes and requirements and include information on a contact point for technical matters.

1.2.2 Drafting recommendation

The designated committee for the relevant part of a Manual or a Guide, supported by the Secretariat, shall validate the stated requirement (unless it is consequential to an amendment to the WMO Technical Regulations) and develop a draft recommendation to respond to the requirement as appropriate.

1.2.3 Procedures for approval

After a draft recommendation of the designated committee is validated in accordance with the procedure given in section 1.7 below, depending on the type of amendments, the designated committee should select one of the following procedures for the approval of the amendments:

- Simple (fast-track procedure) (see 1.3);
- Standard (procedure for the adoption of amendments between CBS sessions) (see 1.4);
- Complex (procedure for the adoption of amendments during CBS sessions) (see 1.5).

1.2.4 Date of implementation

The designated committee should define an implementation date in order to give sufficient time to the WMO Members to implement the amendments after the date of notification. For procedures other than the simple (fast-track) one, if the time between the date of notification and implementation date is less than six months the designated committee shall document the reasons for their decision.

1.2.5 Urgent introduction

Regardless of the above procedures, as an exceptional measure, the following procedure accommodates urgent user needs to introduce elements in lists of technical details, or to correct errors.

(a) A draft recommendation developed by the designated committee shall be validated according to the steps defined in 1.7;

(b) The draft recommendation for pre-operational use of a list entry, which can be used in operational data and products, shall be approved by the chairperson of the designated committee and the chairperson of the responsible OPAG, and the president of CBS. A listing of pre-operational list entries is kept on-line on the WMO web server;

(c) Pre-operational list entries shall then be submitted for approval by one of the procedures in 1.2.3 for operational use;

(d) Any version numbers associated with the technical implementation should be incremented at the least significant level.

1.2.6 Issuing updated version

Once amendments to a Manual or a Guide are adopted, an updated version of the relevant part of the Manual shall be issued in the languages agreed for its publication. The Secretariat shall inform all WMO Members of the availability of a new updated version of that part at the date of notification mentioned in 1.2.4. If amendments are not incorporated into the published text of the relevant Manual or Guide at the time of the amendment, there should be a mechanism to publish the amendments at the time of their implementation and to retain a permanent record of the sequence of amendments.

1.3 Simple (fast-track) procedure

1.3.1 Scope

The simple (fast-track) procedure shall be used only for changes that impact only on those Members wishing to exploit the change.

Note: an example would be the addition of code list items in the *Manual on Codes*.

1.3.2 Endorsement

Draft recommendations developed by the responsible committee, including a date for implementation of the amendments, shall be submitted to the chairperson of the relevant OPAG for endorsement.

1.3.3 Approval

1.3.3.1 Minor adjustments

Correcting typographic errors in descriptive text is considered a minor adjustment, and will be done by the Secretariat in consultation with the president of CBS.

1.3.3.2 Other types of amendments

For other types of amendments, the English version of the draft recommendation, including a date of implementation, should be distributed to the focal points for matters concerning the relevant Manual for comments, with a deadline of two months for the reply. It should then be submitted to the president of CBS for consultation with presidents of technical commissions affected by the change and adoption on behalf of the Executive Council (EC).

1.3.3.3 Frequency

The implementation of amendments approved through the fast track procedure can be twice a year in May and November.

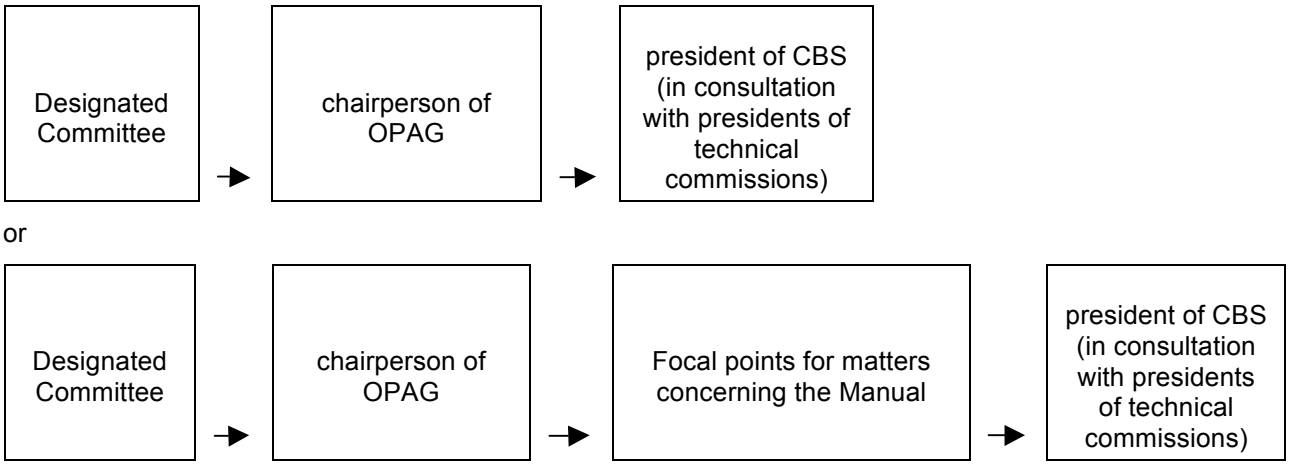


Figure 1 – Adoption of amendments to a Manual by simple (fast-track) procedure

1.4 Standard (procedure for the adoption of amendments between CBS sessions)

1.4.1 Scope

The standard procedure (procedure for the adoption of amendments between CBS sessions) shall be used for changes that have an operational impact on those Members that do not wish to exploit the change, but that have only minor financial impact.

1.4.2 Approval of draft recommendations

For the direct adoption of amendments between CBS sessions, the draft recommendation developed by the designated committee, including a date of implementation of the amendments, shall be submitted to the chairperson of the responsible OPAG and president and vice-president of CBS for approval. The president of CBS shall consult with the presidents of technical commissions affected by the change.

1.4.3 Circulation to Members

Upon approval of the president of CBS, the Secretariat sends the recommendation to all WMO Members, in the languages in which the Manual is published, including a date of implementation of the amendments, for comments to be submitted within two months following the dispatch of the amendments. If the recommendation is sent to Members via electronic mail, there shall be public announcement of the amendment process including dates, for example by WMO Operational Newsletter on the WMO website, to ensure all relevant Members are informed.

1.4.4 Agreement

Those WMO Members not having replied within the two months following the dispatch of the amendments are implicitly considered as having agreed with the amendments.

1.4.5 Coordination

WMO Members are invited to designate a focal point responsible to discuss any comments/ disagreements with the designated committee. If the discussion between the designated committee and the focal point cannot result in an agreement on a specific amendment by a WMO Member, this amendment will be reconsidered by the designated committee. If a WMO Member cannot agree that the financial or operational impact is minor, the redrafted amendment shall be approved by the complex procedure described in Section 1.5.

1.4.6 Notification

Once amendments are agreed by WMO Members, and after consultation with the chairperson of the responsible OPAG, the vice-president of CBS and the president of CBS (who should consult with presidents of other commissions affected by the change), the Secretariat notifies at the same time the WMO Members and the members of the Executive Council of the approved amendments and of the date of their implementation.

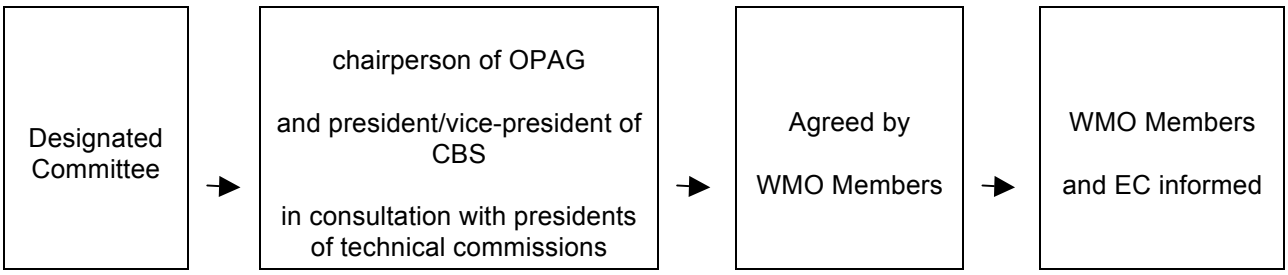


Figure 2 – Adoption of amendments between CBS sessions

1.5 Complex (procedure for the adoption of amendments during CBS sessions)

1.5.1 Scope

The complex procedure (procedure for the adoption of amendments during an Ordinary or Extraordinary CBS session) shall be used for changes for which the simple (fast-track) or standard (procedure for adoption of amendments between CBS sessions) cannot be applied.

1.5.2 Procedure

For the adoption of amendments during CBS sessions, the designated committee submits its recommendation, including a date of implementation of the amendments, to the Implementation/ Coordination Team) of the responsible Open Programme Area Group. The recommendation is then passed to the presidents of technical commissions affected by the change for consultation, and to a CBS session that shall be invited to consider comments submitted by presidents of technical commissions. The document for the CBS session shall be distributed not later than 45 days before the opening of the session. Following the CBS session, the recommendation shall then be submitted to an EC session for decision.

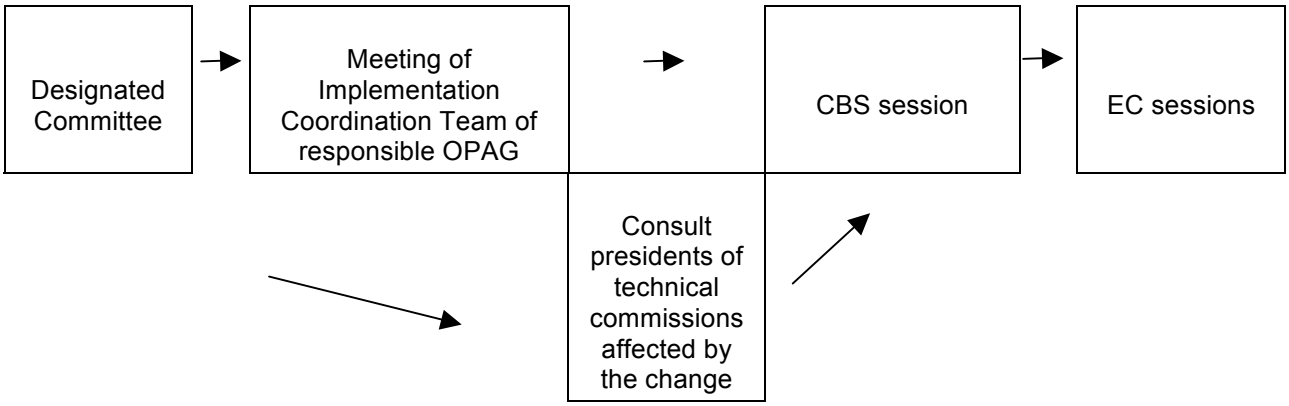


Figure 3 – Adoption of amendments during CBS sessions

1.6 Procedure for the correction of existing Manual contents

1.6.1 Correcting errors in items within Manuals

Where a minor error in the specification of an item that defines elements within a Manual is found (e.g. typing error or incomplete definition) the item shall be amended and re-published. Any version numbers associated with items edited as a result of the change should be incremented at their lowest level of significance. If, however, the change impacts the meaning of the item, then a new item should be created and the existing (erroneous) item marked as deprecated. This situation is considered a minor adjustment according to 1.3.3.1 above.

Note: an example of an item for which this type of change applies is a CodeList entry for the Table Driven Code Forms or WMO Core Metadata Profile whose description contains typographic errors that can be corrected without changing the meaning of the description.

1.6.2 Correcting an error in the specification of how conformance with the requirements of the Manual can be checked

If an erroneous specification of a conformance checking rule is found, the preferred approach is to add a new specification using the simple (fast-track) procedure or standard (procedure for adoption of amendments between CBS sessions) approach. The new conformance checking rule should be used instead of the old. An appropriate explanation shall be added to the description of the conformance checking rule to clarify the practice along with the date of the change.

Note: an example of such a change would be correcting a conformance-checking rule in the WMO Core Metadata Profile.

1.6.3 Submission of corrections to errors

Such changes shall be submitted through the simple (fast-track) procedure.

1.7 Validation procedure

1.7.1 Documentation of need and purpose

The need for, and the purpose of, the proposal for changes should be documented.

1.7.2 Documentation of result

This documentation shall include the results of validation testing of the proposal as described below.

1.7.3 Testing with relevant applications

For changes that impact on automated processing systems, the extent of the testing required before validation should be decided by the designated committee on a case by case basis, depending on the nature of the change. Changes involving a relatively high risk and/or impact on the systems should be tested by the use of at least two independently developed tool sets and two independent centres. In that case results should be made available to the designated committee with a view to verifying the technical specifications.

Annex 2 to Recommendation 15 (CBS-Ext.(2014))

TEXT TO BE REMOVED FROM THE *MANUAL ON CODES* (WMO-No. 306) AND THE *MANUAL ON THE WMO INFORMATION SYSTEM* (WMO-No. 1060)

Remove the following paragraphs from the Introduction of Part I to Volume I.1 of WMO-No. 306 the *Manual on Codes*: Sections numbers 1 to 6 under the heading "PROCEDURES FOR AMENDING THE MANUAL ON CODES".

Remove the following text and diagrams from WMO-No. 1060 the *Manual on the WMO Information System*: Section C.2 of Appendix C.

Annex 3 to Recommendation 15 (CBS-Ext.(2014))

TEXT TO BE AMENDED IN THE *TECHNICAL REGULATIONS* (WMO-No. 49), VOLUME I

Remove following paragraph 15 with note in General Provisions:

15. If a recommendation for an amendment is made by the appropriate technical commission and the implementation of the new regulation is urgent, the President of the Organization may, on behalf of the Executive Council, take action as provided by Regulation 9 (5) of the General Regulations.

Note: A fast-track procedure can be applied for additions to certain codes and associated code tables, contained in Annex II (*Manual on Codes* (WMO-No. 306)). Application of the fast-track procedure is described in detail in Annex II.

Insert following paragraph at the same place:

15. If a recommendation for an amendment is made by the appropriate technical commission and the implementation of the new regulation is urgent, the President of the Organization may, on behalf of the Executive Council, take action as provided by Regulation 9 (5) of the General Regulations. For an amendment with minor financial implication in Annexes II (*Manual on Codes* (WMO-No.306), III (*Manual on the Global Telecommunication System* (WMO-No.386)), IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No.485)), V (*Manual on the Global Observing System* (WMO-No.544)), and VII (*Manual on the WMO Information System* (WMO-No.1060)), the President of the Commission for the Basic Systems may approve it on behalf of Executive Council, as described in Appendix F.

Recommendation 16 (CBS-Ext.(2014))

REGULATORY MATERIAL OF THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 45 (Cg-XVI) – Technical Regulations of the World Meteorological Organization,

(2) The decision of the Executive Council taken at its sixty-fourth session on revision of the *Technical Regulations* (WMO-No. 49) in line with the up-to-date and emerging WMO systems and services,

(3) Resolution 26 (EC-64) – Amendments to the Technical Regulations,

(4) The decision of the Executive Council taken at its sixty-fifth session on the adjustment of the structure of the *Technical Regulations* agreed at its sixty-fourth session,

Noting further that the comments submitted by the Commission for Basic Systems experts were incorporated accordingly in the draft Part I – WMO Integrated Global Observing System (WIGOS) of the *Technical Regulations,* Volume I, and the draft Manual on the WMO Integrated Global Observing System,

Recognizing:

(1) That the Sixteenth World Meteorological Congress emphasized that the implementation of WIGOS must be reflected in the revised *Technical Regulations*, documenting the WIGOS concept of operations and contributions of all component observing systems,

(2) That the Executive Council at its sixty-sixth session agreed that the *Technical Regulations*, Volume I, Part I – WIGOS could be approved and promulgated effectively by the Seventeenth World Meteorological Congress,

Recommends that the *Technical Regulations,* Volume I, Part I – WIGOS and the Manual on WIGOS, as given in Annex 1 and Annex 2, respectively, to the present recommendation, be adopted by Seventeenth Congress, with effect from 1 January 2016;

Authorizes the Secretary-General to make any subsequent changes to the *Technical Regulations*, Volume I, Part I – WIGOS and the Manual on WIGOS when based on comments from Members during the further review process.

Annex 1 to Recommendation 16 (CBS-Ext.(2014))

TECHNICAL REGULATIONS (WMO-No. 49), VOLUME I, PART I – WMO INTEGRATED GLOBAL OBSERVING SYSTEM

WORLD METEOROLOGICAL ORGANIZATION

WMO INTEGRATED GLOBAL OBSERVING SYSTEM (WIGOS)

Technical Regulations

VOLUME I – General Standards and Recommended Practices

(20xx edition)

PART I. WMO Integrated Global Observing System (WIGOS)

(Version 0.8)

DRAFT

VERSION CONTROL

Chair Task Team WIGOS Regulatory Material: Russell Stringer (R.Stringer@bom.gov.au)			
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Version	Summary of change	Source of proposal (name, group, …..) or if this is an "adopted version" enter "Chair TT-WRM"	Date of: = proposal, or = adoption by Chair
0.1	First full compilation of (mostly) completed and reviewed sections, for presentation to ICG-WIGOS-3	Chair TT-WRM	2014-02-06
0.2	Comments & changes for consideration	I. Zahumensky, T. Goos, L. Nunes	2014-03-13
0.3	Review	Russell Stringer, I. Zahumensky, T. Goos, L. Nunes	2014-04-03
0.4	Final editorial	I. Zahumensky	2014-04-09
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0.6	Minor editorial	I. Zahumensky	2014-08-08
0.7	Feedback from Secretariat, and editorial	R. Stringer, M. Ondras, L.P. Riishojgaard, I. Zahumensky	2014-08-27
0.8	CBS-Ext.(2014)	L.P. Riishojgaard	2014-09-11

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DEFINITIONS

Note 1: Other definitions may be found in the *Manual on Codes* (WMO-No. 306), *Manual on the Global Data Processing and Forecasting System* (WMO-No. 485), Volume I, *Manual on the Global Telecommunication System* (WMO-No. 386), Volume I and other WMO publications.

Note 2: These definitions will be added to the definitions provided by other Parts to the full definition set for Volume I.

The following terms, when used in the Volume I of the Technical Regulations, have the meanings given below.

Aircraft meteorological station. Meteorological station situated aboard an aircraft.

Antarctic Observing Network. Comprises all operational networks in Antarctica.

Calibration (rating).

– Experimental determination of the relationship between the quantity to be measured and the indication of the instrument, device or process which measures it.

– Process of relating the indicated response of an instrument to its actuating signal, or to the true value obtained independently; it is usually carried out at several points in the instrument's measurement range.

Climatological station. (1) Station from which climatological data are obtained. (2) Surface station at which observations of specified elements are made primarily for climatological purposes.

Compatibility. A state in which two things are able to exist and be used together without problems or conflict.

Cryosphere. Component of the Earth System that includes solid precipitation, snow cover, sea ice, lake and river ice, glaciers, ice caps, ice sheets, permafrost, and seasonally frozen ground.

Note: While elements of the cryosphere are often defined to contain frozen water, permafrost can be "dry". The Global Cryosphere Watch (GCW) definition includes elements of the cryosphere that occur on or beneath the earth's surface, or that are measured at the surface in the case of solid precipitation. It therefore excludes ice clouds.

Global Cryosphere Watch (GCW) Observing Network. Comprised of GCW sites with varying capabilities built on existing observing programmes and promoting the addition of standardized cryospheric observations to existing facilities. It covers all components of the cryosphere: glaciers, ice shelves, ice sheets, snow, permafrost, sea ice, river/lake ice, and solid precipitation.

CryoNet. The core of the GCW observing network that applies GCW agreed observing practices. It comprises sites in cold climate regions, on land or sea, operating a sustained, standardized programme for observing and monitoring as many cryospheric variables as possible. CryoNet is being structured in three different classes of observational sites: Baseline sites, Reference sites, and Integrated sites.

Discovery metadata. Metadata consistent with the standard that is used within WMO Information System (WIS) for discovery of information shared through WIS.

Framework. A set of principles, ideas, guidelines and provisions to enable decisions, judgments and operations.

Geostationary Earth Orbit (GEO). Satellites in geostationary Earth orbits are often referred to as GEOs

Geostationary satellite. Meteorological satellite orbiting the Earth at an altitude of approximately 36 000 km with the same angular velocity as the Earth and within the equatorial plane, thus providing nearly continuous information in an area within a range of about 50° from a fixed sub-satellite point at the Equator.

Global Climate Observing System (GCOS). A long-term, user-driven operational system capable of providing the comprehensive observations required for:

– Monitoring the climate system,

– Detecting and attributing climate change,

– Assessing impacts of, and supporting adaptation to, climate variability and change,

– Application to national economic development,

– Research to improve understanding, modelling and prediction of the climate system.

Instrument. Device used for making measurements, alone or in conjunction with one or more supplementary devices.

In situ observation. Observation made by a device that is in physical or direct contact with the object or phenomenon under study.

Interoperability. The ability of diverse systems to work together (inter-operate).

Low Earth Orbits (LEO). An orbit with an altitude between 160 kilometres (99 mi), with a period of about 88 minutes, and 2,000 kilometres (1,200 mi), with a period of about 127 minutes.

Meteorological observation. Evaluation or measurement of one or more meteorological elements.

Meteorological observing network. A group of meteorological observing stations spread over a given area for a specific purpose.

Meteorological observing station (Meteorological station). Place where meteorological observations are made with the approval of the WMO Member or Members concerned.

Meteorological report (Report). Statement of observed meteorological conditions related to a specific time and location.

Near-polar orbiting satellite. A meteorological satellite with a nearly circular, nearly polar orbit. The combination of satellite motion and the Earth's rotation beneath the orbit provides overlapping strips of satellite data covering swaths (up to 3000 km) from pole to pole. The satellite's altitude can be chosen within a wide range (600 to 1500 km) in order to provide data over the entire globe twice a day.

Observation. Evaluation of one or more elements of the physical environment.

Note: Observations are level II data and may be obtained directly or derived, as defined in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485, 2010 edition), Volume I – Global Aspects"

Observational data. The result of the evaluation of one or more elements of the physical environment.

Observational Metadata. Descriptive data about observational data; information that is needed to assess and interpret observations or to support design and management of observing systems and networks.

Observation network. One or more sensors, instruments or types of observation at more than one station or platform, acting together to provide a coordinated set of observations.

Observing platform. A place where observations are made; it refers to all types of observing stations and platforms, whether they are surface-based, or space-based, on land, at sea/lake/river, or in the air, fixed, or mobile (including in the air), and making in-situ or remote observations.

Note: The owner and operator of an observing platform may be a National Meteorological and/or Hydrological Service, another agency or organization (either governmental, non-governmental or commercial) or an individual.

Observing station. A place where observations are made; it refers to all types of observing stations and platforms, whether they are surface-based, or space-based, on land, at sea/lake/river, or in the air, fixed, or mobile (including in the air), and making in-situ or remote observations.

Note: The owner and operator of an observing station may be a National Meteorological and/or Hydrological Service, another agency or organization (either governmental, non-governmental or commercial) or an individual.

Observing (or Observation) system. A coordinated system of methods, techniques and facilities for making observations using one or more sensors, instruments or types of observation at one or more stations and platforms, acting together to provide a coordinated set of observations.

Near-real time observation. An observation which is available to a user soon after the observation is completed.

Note: The time-lags considered to be “real-time”, “near-real-time” or "non-real-time" are different in different situations and depend on several factors. A near-real-time observation is essentially a real-time observation with an identifiable delay which reduces its value to some users.

Non-real time observation. An observation which is not available to a user immediately or soon after the observation is completed, but at some later time. It informs the user of conditions that prevailed at an earlier time.

Note: The time-lags considered to be “real-time”, “near-real-time” or "non-real-time" are different in different situations and depend on several factors. Factors include the user application, the dissemination method, intervening quality control or other processing steps, the frequency and sampling time of the observation, and the variability of the physical element observed.

Real time observation. An observation which is available to a user immediately after the observation is completed. It informs the user of the current conditions.

Note: The time-lags considered to be “real-time”, “near-real-time” or "non-real-time" are different in different situations and depend on several factors. A key factor is the requirement of the user application, such that an observation not available quickly enough for immediate operational use (within seconds, or minutes, or hours, or for some applications days) might not be regarded as real-time for that application. Some other factors are whether the dissemination method used is the most direct and rapid possible, whether quality control or other processing steps delay availability, whether the time lag is reasonably proportionate to the frequency of observation or the sampling time taken to collect the observation, and whether the time lag is reasonably proportionate to the variability of the physical element observed.

Remote sensing. Observation made by a device that is not in physical or direct contact with the object or phenomenon under study.

Satellite systems. A space system using one or more artificial satellites orbiting the Earth.

System. Assembly of objects, processes or concepts, most often interacting with each other, which are focussed on or result in a specific outcome.

WMO Observing station/platform. Any observing station/platform currently issued with a valid WMO identifier.

WMO Observing system/observations network. An observing system/observations network consisting of WMO stations and platforms.

WMO Observation. An observation made at a WMO observing station/platform.

1. INTRODUCTION TO WIGOS

1.1 Purpose of WIGOS

1.1.1 The WMO Integrated Global Observing System (WIGOS) shall be a framework for all WMO observing systems and the contributions of WMO to co-sponsored observing systems in support of all WMO programmes and activities.

Note: The co-sponsored observing systems are the WMO-IOC-UNEP-ICSU Global Climate Observing System (GCOS), the WMO-IOC-UNEP-ICSU Global Ocean Observing System (GOOS) and the WMO-IOC-UNEP-ICSU Global Terrestrial Observing System (GTOS).

1.1.2 The WIGOS shall facilitate the use by WMO of observations from systems that are owned, managed and operated by a diverse array of organizations and programmes.

1.1.3 The principal purpose of WIGOS shall be to meet the evolving requirements of Members for observations.

Note: The assessments of requirements and plans to meet them are achieved through the application of the Rolling Review of Requirements (RRR) process according to the *Manual on WIGOS* (WMO-No. XXXX), sections 2.1 and 2.2.

1.1.4 Within WIGOS, Members shall collaborate to advance the state of observing systems, their compatibility and the worldwide exchange of observations, with additional benefits emerging as the concept is adopted by entities beyond WMO itself and its partner organizations.

1.1.5 Members should enhance collaboration and cooperation amongst meteorological, hydrological, marine, oceanographic and other related academic and research institutions and services at the national level, in order to meet the goals listed in 1.1.3.

1.1.6 The WIGOS framework shall focus on the integration of governance and management functions, mechanisms and activities to be accomplished by contributing observing systems on a global, regional and national level.

1.2 WIGOS component observing systems

1.2.1 The component observing systems of WIGOS shall comprise the Global Observing System (GOS) of the World Weather Watch (WWW) Programme, the observing component of the Global Atmosphere Watch (GAW) Programme, the WMO Hydrological Observing System (WHOS) of the Hydrology and Water Resources Programme (HWRP) and the observing component of the Global Cryosphere Watch (GCW), including their surface-based and space-based components.

Note 1: The above component systems include all WMO contributions to the co-sponsored systems, as well as the WMO contributions to the Global Framework for Climate Services (GFCS) and Global Earth Observation System of Systems (GEOSS).

Note 2: WIGOS component observing systems have individual identities and stakeholder communities, but also support a single collective identity of all WMO observing systems including co-sponsored systems as the WIGOS.

1.2.1 Global Observing System of the World Weather Watch

1.2.1.1 The Global Observing System (GOS) shall be a coordinated system of networks of observing stations and platforms, together with methods, techniques, facilities and arrangements for making observations on a worldwide scale and defined as one of the main components of the World Weather Watch Programme.

1.2.2 Global Atmosphere Watch (observing component)

1.2.2.1 The Global Atmosphere Watch (GAW) shall be a coordinated system of networks of observing stations, methods, techniques, facilities and arrangements encompassing the many monitoring and related scientific assessment activities devoted to the investigation of the changing chemical composition and related physical characteristics of the global atmosphere.

1.2.3 WMO Hydrological Observing System

1.2.3.1 The WMO Hydrological Observing System (WHOS) shall comprise hydrological observations, initially focusing on water level and discharge, and shall include the World Hydrological Cycle Observing System programme (WHYCOS) intended to improve basic observation activities, strengthen international cooperation and promote the free exchange of data in the field of hydrology.

Note: The composition of hydrological observations is provided in Volume III – Hydrology, Chapter D.1.2 of the WMO *Technical Regulations* (WMO-No. 49).

1.2.3.2 The purpose of the WHOS shall be to provide real time streamflow data (both water level and discharge) from participating National Hydrological Services.

1.2.3.3 Members providing hydrological observations to the WHOS shall operate in accordance with the procedures and practices set out in the following sections (2, 3, 4 and 8) of the Volume I, Part I.

1.2.4 Global Cryosphere Watch (observing component)

1.2.4.1 The Global Cryosphere Watch (GCW) shall be a coordinated system of networks of observing stations, methods, techniques, facilities and arrangements encompassing monitoring and related scientific assessment activities devoted to the investigation of the changing Cryosphere.

1.2.4.2 The GCW observing network and its standardized core network (CryoNet) shall build on existing observing programmes and promote the addition of standardized cryospheric observations to existing facilities.

Note 1: The GCW Implementation Plan available at: http://globalcryospherewatch.org/reference/documents/ provides more information.

Note 2: Existing Cryosphere observing programmes include cryospheric observational programs within WMO programmes (including the Joint WMO/IOC Technical Commission on Oceanography and Marine Meteorology (JCOMM)), the co-sponsored Programmes (GCOS, GTOS, GOOS) and including, but are not limited to, observational programmes of the International Permafrost Association (IPA), the World Glacier Monitoring Service (WGMS), a service of the International Association of Cryospheric Sciences (IACS), the Scientific Committee for Antarctic Research (SCAR), and the Global Precipitation Climatology Centre (GPCC), and the US National Snow and Ice Data Center (NSIDC).

1.3 Collaboration with partners responsible for co-sponsored and non-WMO observing systems

1.3.1 Members shall support the collaboration between the WMO and its international partners responsible for the co-sponsored and non-WMO observing systems.

1.3.2 Members shall implement similar cooperation and coordination arrangements among National Meteorological and Hydrological Services (NMHSs) and through national mechanisms for GFCS, GCOS, GOOS, GTOS, and GEOSS.

1.4 Governance and management

Note: WIGOS implementation is an integrating activity for all WMO and co-sponsored observing systems: it supports all WMO Programmes and activities. The Executive Council and regional associations, supported by their respective

working bodies, have a governing role in the implementation of WIGOS. Technical aspects of WIGOS implementation are guided by the technical commissions, with leadership provided through CBS and CIMO. The Sixteenth World Meteorological Congress (Cg-XVI) made decisions for the governance and management of WIGOS. [Resolution 50 (Cg-XVI) – Implementation of the WMO Integrated Global Observing System]

1.4.1 Members shall implement and manage their national observing systems in accordance with the provisions of the *Technical Regulations*, Volume I, Part I, and the *Manual on WIGOS* (WMO-No. XXXX).

2. COMMON ATTRIBUTES OF WIGOS COMPONENT SYSTEMS

2.1. Requirements

2.1.1 General

2.1.1.1 Members shall establish, operate and maintain their national observing systems to address observational requirements in an integrated, coordinated and sustainable manner.

2.1.2 Observational requirements

2.1.2.1 Members shall convey their observational user requirements, for each of the WMO application areas, to the Rolling Review of Requirements (RRR) process.

Note: Details on the Rolling Review of Requirements (RRR) process and the WMO application areas are given in the *Manual on WIGOS* (WMO-No. XXXX), sections 2.1 and 2.2.

2.2. Design, planning and evolution

2.2.1 General

2.2.1.1 Members, both directly and through the participation of their experts in the activities of regional associations and technical commissions, shall contribute to the Rolling Review of Requirements (RRR) process.

2.2.1.2 Members should implement the plans published by WMO for evolution of WIGOS component observing systems when planning and managing their observing systems.

2.2.1.3 Members shall maintain close coordination with their national telecommunication authorities to register their frequencies for adequate protection and to defend the availability of frequencies for all WIGOS component observing systems.

2.3. Instrumentation and Methods of Observation

2.3.1 General

Note: Standard and recommended practices and procedures with respect to instruments and methods of observation across and within all WIGOS component observing systems are specified in the *Technical Regulations* (WMO-No. 49), Volume I – III, and detailed in the *Manual on WIGOS* (WMO-No. XXXX).

2.4 Operations

2.4.1 General Requirements

2.4.1.1 Members shall install, operate and maintain their WIGOS component observing systems in accordance with the *Technical Regulations* (WMO-No. 49, Volume I–IV), the *Manual on WIGOS* (WMO-No. XXXX).

2.4.1.2 Members shall ensure the continuity of operation and availability of observations generated by the observing systems under their responsibility.

2.4.1.3 Members shall ensure that proper safety practices and procedures for operation of observing systems are specified, documented and utilized.

Note: Safety practices and procedures are those that are concerned with assuring the welfare of staff while promoting overall efficiency and effectiveness of the NMHS and responding to national laws, regulations and requirements for occupational health and safety.

2.4.2 Observations

2.4.2.1 Members shall ensure overall availability of observations for all WMO Application Areas in accordance with these Technical Regulations and the *Manual on WIGOS* (WMO-No. XXXX).

Note 1: The WMO Application Areas are detailed in section 2.1 of the *Manual on WIGOS* (WMO-No. XXXX).

Note 2: Special focus is to be given to meet the requirements of numerical weather prediction since many application areas depend on it.

Note 3: Special focus is to be given to climate monitoring, including the observational requirements of the Global Framework for Climate Services, which is one of the priority areas for WMO.

2.4.2.2 Members should ensure timely, quality-assured, quality-controlled, and well-documented compatible long-term observations in accordance with the practices and procedures specified in these Technical Regulations and the *Manual on WIGOS* (WMO-No. XXXX).

Note: Technical specifications and details are given mainly in the G*uide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), *Guide to Climatological Practices* (WMO-No. 100), *Guide to Hydrological Practices* (WMO-No. 168), Volume I: Hydrology – From Measurement to Hydrological Information, *Guide on the Global Data-Processing Systems* (WMO-No. 305), and *Guide to the Global Observing System* (WMO-No. 488).

2.4.3 Performance

2.4.3.1 Members shall continuously monitor the performance of their observing systems.

2.4.3.2 Members should maintain records of the performance monitoring as part of their Quality Management System, for auditing purposes, where appropriate, in accordance with section 2.6 of these Technical Regulations and the *Manual on WIGOS* (WMO-No. XXXX).

Note: Technical specifications and details are given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), *Guide to Climatological Practices* (WMO-No. 100), *Guide to Hydrological Practices* (WMO-No. 168), Volume I: Hydrology – From Measurement to Hydrological Information, and *Guide to the Global Observing System* (WMO-No. 488).

2.4.4 Quality Control

2.4.4.1 Members shall implement quality control for all observations for which they are responsible.

Note: Minimum set of standards of quality control for meteorological data are specified in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), Volume I.

2.4.4.2 Members not capable of implementing quality control should establish agreements with an appropriate national, regional or global organization or centre to perform the necessary quality control.

2.4.5 Calibration

2.4.5.1 Members shall perform calibration of *their systems and instruments traceable to an international standard in accordance with the Manual on WIGOS* (WMO-No. XXXX).

2.5. Observational Metadata

2.5.1 Members shall record, retain and make available internationally the observational metadata as specified in the *Manual on WIGOS* (WMO-No. XXXX), section 2.5.

2.6. Quality Management

2.6.1 Members shall comply with the standard and recommended practices and procedures with regard to the quality of WIGOS observations and observational metadata, as detailed in these Technical Regulations and in the *Manual on WIGOS* (WMO-No. XXXX).

Note: Provisions relating to the WMO Quality Management Framework are provided in the *Technical Regulations*, (WMO-No. 49), 2011 edition, Volume IV – Quality Management (WMO-No. 49), 2011 edition.

2.7. Capacity Development

2.7.1 General

2.7.1.1 Members should undertake efforts in capacity development to ensure that their observing systems comply with the standard and recommended practices and procedures specified by the WMO *Technical Regulations* (WMO-No. 49).

Note: Guidance on approaches for capacity development is found in the *WMO Capacity Development Strategy* (WMO-No. 1092) and its Implementation Plan (WMO-No. 1118). Such guidance includes consideration of various types of capacity: institutional, infrastructural, procedural and human resources.

2.7.2 Training

2.7.2.1 Members shall ensure that their personnel involved in WIGOS related activities are educated and trained to comply with the WIGOS standard and recommended practices and procedures.

Note: Extensive provisions applicable to the education and training of personnel are defined in Part V and Part VI of these Technical Regulations, and the *Manual on the Implementation of Education and Training Standards in Meteorology and Hydrology* (WMO-No. 1083), Volume I.

2.7.3 Infrastructural Capacity Development

2.7.3.1 Members should regularly review their observing infrastructure and pursue capacity development activities to upgrade them, as required to address the priorities for evolution of observing systems identified through the Rolling Review of Requirements process as well as any additional national priorities.

Note: The Rolling Review of Requirements process and the resulting priorities for evolution of observing systems are described in sections 2.1 and 2.2 above.

3. COMMON ATTRIBUTES SPECIFIC TO THE SURFACE-BASED SUBSYSTEM OF WIGOS

3.1. Requirements

3.1.1 General

3.1.1.1 The WIGOS surface-based subsystem shall be composed of stations and platforms within the component networks (i.e. GOS, GAW, GCW, and WHOS) as described in the *Manual on WIGOS* (WMO-No. XXXX).

3.1.1.2 Members should establish and operate their surface-based subsystem as a single composite system of observing stations and platforms.

3.1.2 Observational requirements

3.1.2.1 Members shall establish, operate, and maintain surface-based observing systems to meet the requirements of the WMO Application Areas, in accordance with section 2.1 of the *Manual on WIGOS* (WMO-No. XXXX).

3.2. Design, planning and evolution

3.2.1 General

3.2.1.1 Members shall plan, implement, operate and maintain national networks and observing programmes based on the standard and recommended practices and procedures as stated in the WMO Technical Regulations, including the *Manual on WIGOS* (WMO-No. XXXX).

Note: Members are urged to take into account various plans and strategies developed by WMO for WIGOS and the component observing systems.

3.2.1.2 Members should cooperate to address regional implementation of observing networks or systems.

3.2.1.3 Members should adopt a composite network approach to their networks and include observations from a range of sources, including NMHSs and other government agencies, academic and research institutes, the commercial sector and the public.

Note 1: The composite network approach here means the use of various types of observing systems or sources of observations to deliver a combined set of observations.

Note 2: In all cases users are to judge the suitability of observations for their intended application, through assessment of available metadata, which includes the identification of the source. Section 2.5 of the *Manual on WIGOS* (WMO-No. XXXX) describes the required metadata.

3.3. Instrumentation and Methods of Observation

3.3.1 General

Note: Standard and recommended practices and procedures with respect to instruments and methods of observation for all WIGOS surface-based subsystems are specified in the *Technical Regulations* (WMO-No. 49), Volume I - III, and detailed in the *Manual on WIGOS* (WMO-No. XXXX).

3.4. Operations

3.4.1 General

3.4.1.1 Members should ensure that operators of observing systems comply with the WMO *Technical Regulations* (WMO-No. 49, Volume I-IV) and the *Manual on WIGOS* (WMO-No. XXXX).

Note: System operators are generally NMHSs or other organizations within WMO Member countries but are sometimes other entities.

3.5. Observational Metadata

3.5.1 Members operating surface-based observing systems shall follow the provisions of the section 2.5.

3.6. Quality Management

3.6.1 Members operating surface-based observing systems shall follow the provisions of the section 2.6.

3.7. Capacity Development

3.7.1 Members operating surface-based observing systems shall follow the provisions of the section 2.7.

4. COMMON ATTRIBUTES SPECIFIC TO THE SPACE-BASED SUBSYSTEM OF WIGOS

4.1 Scope, purpose and operation of the space-based subsystem

4.1.1 General

Note: Space-based observations, i.e. data obtained from satellite systems, are a fundamental asset for meteorology, climatology and hydrology, both for operational and research applications.

4.1.2 Observational requirements

4.1.2.1 Satellite operators shall establish, operate, maintain and ensure the continuation of satellite systems, providing observational information as specified in the *Manual on WIGOS* (WMO-No. XXXX).

Note 1: The term “satellite operators” is used in Vol. I. Part I to refer to “Members or a coordinated group of Members operating environmental satellites”.

Note 2: A coordinated group of Members operating environmental satellites is a group of Members acting jointly to operate one or more satellites through an international space agency such as the European Space Agency or EUMETSAT.

4.1.2.2 To ensure global coverage, contingency support and to meet further requirements as stated in the *Manual on WIGOS* (WMO-No. XXXX), satellite operators shall cooperate and arrange an optimal constellation of satellite systems, including but not restricted to near-polar-orbiting and geostationary platforms.

Note: These requirements are compiled through the Rolling Review of Requirements (RRR) process (see the *Manual on WIGOS* (WMO-No. XXXX), sections 2.1 and 2.2.), and are expressed in terms of coverage, continuity, resolution, uncertainty, frequency and observational variables.

4.1.2.3 Satellite operators shall process observational data up to a level as required by the *Manual on* WIGOS (WMO-No. XXXX) and shall do so in a timely manner for dissemination in near real-time.

4.1.2.4 Satellite operators shall report data as observed variables, defined in the *Manual on WIGOS* (WMO-No. XXXX) and expressed by environmental quantities in International Standards (SI) units.

5. OBSERVING COMPONENT OF THE GLOBAL ATMOSPHERE WATCH

5.1 The mission of the Global Atmosphere Watch (GAW) shall be to:

(a) Reduce environmental risks to society and meet the requirements of environmental conventions.

(b) Strengthen capabilities to predict climate, weather and air quality.

(c) Contribute to scientific assessments in support of environmental policy.

through:

(a) Maintaining and applying global, long-term observations of the chemical composition and selected physical characteristics of the atmosphere.

(b) Emphasizing quality assurance and quality control.

(c) Delivering integrated products and services of relevance to users.

5.2 The Global Atmosphere Watch observational network shall be developed and implemented in accordance with the provisions set out in the *Manual on WIGOS* (WMO-No. XXXX).

5.3 The Global Atmosphere Watch observations shall be carried out in accordance with the provisions set out in the *Technical Regulations* (WMO-No. 49), Volume I, Part II, section 2, the *Manual on WIGOS* (WMO-No. XXXX) and the *Manual on the Global Observing System* (WMO-No. 544), Volume I.

Note 1: Members may perform observations of any of the parameters included in the GAW focal areas: ozone, greenhouse gases, reactive gases, aerosols, UV radiation and precipitation chemistry, using observation modes such as in situ, vertical distribution and total column.

Note 2: Members may use different platforms or their combinations, e.g. fixed stations, mobile platforms and remote sensing to perform atmospheric composition measurements.

5.4. Members shall register their contribution in the GAW station information system (GAWSIS), and submit their observations to the relevant GAW Data Centre.

Note: GAW Data Centres are specified by the GAW Strategic Plan: 2008–2015 (GAW Report No. 172) and its Addendum (GAW Report No. 197).

6. OBSERVING COMPONENT OF THE GLOBAL CRYOSPHERE WATCH

6.1 The purpose of the Global Cryosphere Watch (GCW) shall be to provide data and other information on the cryosphere from a local to the global scale to improve understanding of its behaviour, interactions with other components of the climate system, and impacts on society.

6.2 The observing component of the Global Cryosphere Watch shall be a coordinated system of observing stations, facilities and arrangements encompassing monitoring and related scientific assessment activities devoted to the Cryosphere.

6.3 The development of the GCW observing network and its core network (CryoNet) that applies GCW agreed practices and standards shall build on existing observing programmes and promote the addition of standardized cryospheric observations to existing facilities.

6.4 The Global Cryosphere Watch observing network shall be developed and implemented in accordance with the provisions set out in the *Manual on WIGOS* (WMO-No. XXXX)

Note 1: Members may perform observations of any of the parameters describing the state of the GCW cryospheric components (snow, solid precipitation, permafrost, glaciers and ice caps, ice sheets, sea ice, lake and river ice).

Note 2: Members may use different platforms or their combinations (fixed stations, mobile platforms, virtual sites and remote sensing) to perform cryospheric measurements.

6.5 For all stations and platforms which provide GCW observations, Members shall register the station in the GCW station information system at the GCW website (www.globalcryospherewatch.org), and submit those observations to the GCW Portal.

7. GLOBAL OBSERVING SYSTEM OF THE WORLD WEATHER WATCH

7.1 The purpose of the Global Observing System (GOS) shall be to provide the meteorological and related environmental observations from all parts of the globe that are required by Members for operational and research purposes.

7.2 The Global Observing System shall be constituted as a coordinated system of methods, techniques and facilities for making observations on a worldwide scale and defined as one of the main components of the World Weather Watch.

7.3 The Global Observing System shall be composed of integrated subsystems: the surface-based subsystem and the space-based subsystem.

7.4 The surface-based subsystem shall be composed of the regional basic synoptic networks and the Antarctic Observing Network of surface and upper-air stations, climatological stations, Global Climate Observing System stations, Aircraft meteorological stations, and other types of stations and special stations as detailed in the *Manual on the Global Observing System* (WMO-No. 544), Volume I.

7.5 The space-based subsystem shall be composed of three elements: (a) a space segment with (i) operational satellites on Geostationary Earth Orbit (GEO); (ii) operational satellites on distributed, sun-synchronous, Low Earth Orbits (LEO); (iii) other operational or sustained satellites or instruments on appropriate orbits; (iv) research and development (R&D) satellites; (b) an associated ground segment for data reception, dissemination, and stewardship; and (c) a user segment.

7.6 The Global Observing System shall be established and operated in accordance with the provisions set out in the *Manual on the Global Observing System* (WMO-No. 544), Volume I, *Manual on WIGOS* (WMO-No. XXXX), and in the *International Cloud Atlas* (WMO-No. 407), Volume I – Manual on the Observation of Clouds and Other Meteors.

8. WMO HYDROLOGICAL OBSERVING SYSTEM

8.1 The purpose of the WMO Hydrological Observing System (WHOS) shall be to provide the hydrological observing component in fulfilment of the WIGOS objective by facilitating on-line access to already available real-time and historical data, drawing from the water information systems of Members that make their data available on a free and unrestricted basis.

8.2 The WMO Hydrological Observing System shall be constituted as a coordinated system of methods, techniques and facilities for making hydrological observations on a worldwide scale.

8.3. The WMO Hydrological Observing System and the practice of obtaining hydrological observations shall be developed and implemented in accordance with the provisions set out in the *Manual on WIGOS* (WMO-No. XXXX).

Annex 2 to Recommendation 16 (CBS-Ext.(2014))

MANUAL ON THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM

WORLD METEOROLOGICAL ORGANIZATION

MANUAL ON THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM (WIGOS)

Annex IX to the WMO Technical Regulations

(20xx edition)

(Version 0.10)

DRAFT

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INTRODUCTION

PURPOSE AND SCOPE

1. The Manual is designed:

(a) To specify obligations of Member countries in the implementation and operation of the WIGOS;

(b) To facilitate cooperation in observations between Member countries;

(c) To ensure adequate uniformity and standardization in the practices and procedures employed in achieving (a) and (b) above.

2. The Manual is an Annex to the WMO Technical Regulations and should be read in conjunction with the four Volumes and the set of Annexes which together comprise the Technical Regulations. In particular the *Manual on the GOS* (WMO-No. 544) is closely related and will over time disappear as its content is progressively moved into this Manual.

3. Members will implement and operate their observing systems in accordance with decisions of Congress, the Executive Council, the technical commissions and regional associations. Where those decisions are technical and regulatory in nature, they will in due course be documented in the Technical Regulations.

4. This is the first edition of the Manual on the WMO Integrated Global Observing System (WIGOS), developed following the decision of the Sixteenth World Meteorological Congress to proceed with the implementation of WIGOS, approved by the Seventeenth World Meteorological Congress and issued as the 2015 edition.

5. The Manual was developed by the Executive Council through its Inter-Commission Coordination Group on WIGOS (ICG-WIGOS), specifically its Task Team on WIGOS Regulatory Material (TT-WRM). This represents a collaborative approach involving all interested technical commissions under the technical leadership provided through CBS and CIMO.

6. Gradually, all technical regulations for all WMO component observing systems will be included under the identity of WIGOS. For reasons of practicality, the *Manual on the GOS* (WMO-No. 544) is a companion to this Manual during a certain period. However all the practices will over time be described in this Manual.

7. In essence, the Manual specifies what is to be observed, following what practices and procedures, in order to meet the relevant observational requirements of Members. These requirements may arise directly at a national level or collectively through WMO Programmes at global or regional levels, and are expressed through the Application Areas of the Rolling Review of Requirements process. A number of other Manuals and Guides provide more practices and procedures on the operation of observing systems including stations and platforms, instruments and methods of observation, and the reporting and management of observation and observational metadata.

TYPES OF REGULATION

8. The Manual comprises ***standard*** practices and procedures (**standards**), and ***recommended*** practices and procedures (**recommendations**). The definitions of these two types are as follows:

9. The ***standard*** practices and procedures:

(a) Are those practices and procedures which it is ***necessary*** that Members follow or implement; and therefore

(b) Have the status of ***requirements*** in a technical resolution in respect of which ***Article 9 (b)*** of the Convention is ***applicable***; and

(c) Are invariably distinguished by the use of the term ***shall*** in the English text and by suitable equivalent terms in the French, Russian and Spanish texts.

10. The ***recommended*** practices and procedures:

(a) Are those practices and procedures which it is ***desirable*** that Members follow or implement; and therefore

(b) Have the status of ***recommendations*** to Members to which ***Article 9 (b)*** of the Convention ***shall not be applied***; and

(c) Are distinguished by the use of the term ***should*** in the English text (except where specifically otherwise provided by decision of Congress) and by suitable equivalent terms in the French, Russian and Spanish texts.

11. In accordance with the above definitions, Members shall do their utmost to implement the standard practices and procedures. In accordance with Article 9 (b) of the Convention and in conformity with the provisions of Regulation 128 of the General Regulations, Members shall formally notify the Secretary-General, in writing, of their intention to apply the "standard practices and procedures" of the Manual, except those for which they have lodged a specific deviation. Members shall also inform the Secretary-General, at least three months in advance, of any change in the degree of their implementation of a "standard practice or procedure" as previously notified and of the effective date of the change.

12. In the case of hydrological observations, there is not a widely implemented base of global exchange and global standard practices and procedures. Technical Regulations Volume III - Hydrology provides Members with predominately recommended practices and procedures to be followed. In order to help ensure the quality and comparability of observations within WIGOS, Members making their hydrological observations available through the WMO Hydrological Observing System (WHOS) are requested to comply with the provisions specified within this Manual. For this reason, a number of provisions listed herein which are recommended practices and procedures for hydrology in Technical Regulations Volume III – Hydrology have become standard practices and procedures, similar to efforts made by Members for the other WIGOS component observing systems. It is recognized that some of the WIGOS standard practices and procedures might not easily be widely and quickly implemented by all Members for their hydrological observations. Nonetheless, Members are urged to make their best efforts to implement the WIGOS standard practices and procedures in the collection and exchange of hydrological observations and to make such observations available through WHOS.

13. With regard to the recommended practices and procedures, Members are urged to comply with these, but it is not necessary to notify the Secretary-General of non-observance.

14. In order to clarify the status of the various regulatory material, the standard practices and procedures are distinguished from the recommended practices and procedures by a difference in typographical practice, as indicated in the Editorial note.

APPENDICES

15. Material presented in Appendices has full status as part of the Technical Regulations. Appendices are used where a set of provisions on a single topic might, due to their detailed nature and length, otherwise interrupt the flow of the relevant section of this Manual. Also, Appendices are used to facilitate the ongoing review and update process by identifying sub-sections which fall under the specific responsibility of a particular group.

NOTES AND ATTACHMENTS

16. Notes and Attachments are included in the Manual for explanatory purposes. They do not have the status of WMO Technical Regulations.

17. The words "shall" and "should" in any notes and attachments have their dictionary meanings and do not have the regulatory character of standard and recommended practices and procedures mentioned above.

EDITORIAL NOTE[1]

The following typographical practice has been followed:

Standard practices and procedures have been printed in Arial bold.

Recommended practices and procedures have been printed in Arial.

Notes have been printed in smaller type, Arial, and preceded by the indication: Note.

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[1] This Editorial Note will be applied for the distribution of the Drafts to WMO Members.

DEFINITIONS

Note 1: Other definitions related to observing systems may be found in the Volume I of the WMO Technical Regulations and the *Manual on the GOS* (WMO-No. 544). Definitions are not duplicated between Manuals hence it is important to consult all documents.

Note 2: Further definitions may be found in the *Manual on Codes* (WMO-No. 306), *Manual on the Global Data Processing and Forecasting System* (WMO-No. 485), Volume I, *Manual on the Global Telecommunication System* (WMO-No. 386); Volume I, and other WMO publications.

Note 3: Definitions, terminology, vocabulary and abbreviations used in relation to quality management are those of the IOS 9000 family of standards for quality management systems, in particular those identified within ISO 9000:2005, Quality Management Systems – Fundamentals and vocabulary.

The following terms, when used in the *Manual on WIGOS* (WMO-No. XXXX), have the meanings given below.

Accuracy. The extent to which the results of the readings of an instrument approach the true value of the calculated or measured quantities, supposing that all possible corrections are applied.

Accreditation. The formal recognition by an independent body, that the staff has been trained and have mastered the processes to meet the requirements. Accreditation is not mandatory but it adds another level of confidence, as 'accredited' means the certification body has been independently checked to make sure it operates according to international standards.

Acoustic Doppler Current Profiler (ADCP). Hydroacoustic current meter to measure the velocity of water over a range of depths in a column using the Doppler Effect, with the overall depth of water usually being measured simultaneously.

Acoustic Velocity Meter. System that uses the difference in travel time of acoustic (ultrasonic) pulses between transducers in a stream to determine the mean velocity on the signal path.

Adaptive maintenance. Modification of an instrument, software etc. performed after installation to keep the product usable in a changed or changing environment.

Bank. (1) Rising land bordering a river, usually to contain the stream within the wetted perimeter of the channel. (2) Margin of a channel at the left-hand (right-hand) side when facing downstream.

Cableway. Cable stretched above and across a stream, from which a current meter or other measuring or sampling device is suspended, and moved from one bank to the other, at predetermined depths below the water surface.

Calibration (rating) Tank. ***(Straight Open Tanks)*** Tank containing still water through which a current meter is moved at a known velocity for calibrating the meter.

Catchment Area. Area having a common outlet for its surface runoff.

Certification. The provision by an independent body, generally known as an accreditation body, of written assurance (a certificate) that the product, service or system in question meets specific requirements.

Compliance. May be an internal code of conduct where employees follow the principles of one of the Quality Management Standards series (such as the ISO standards) or other internationally recognized practices and procedures. It may also represent an external stamp of approval by an accreditation firm when customers or partners request documented proof of compliance.

Confidence Level. Probability that the confidence interval includes the true value.

Control. Physical properties of a channel which determine the relationship between stage and discharge at a location in the channel.

Control Structures. Artificial structure placed in a stream such as a low weir or flume to stabilize the stage-discharge relation, particularly in the low flow range, where such structures are calibrated by stage and discharge measurements taken in the field.

Co-sponsored observing system. An observing system from which some but not all observations are WMO observations

Cross-section. Section perpendicular to the main direction of flow bounded by the free surface and wetted perimeter of the stream or channel.

Current meter. Instrument for measuring water velocity.

Current meter, propeller type. A current meter the rotor of which is a propeller rotating around an axis parallel to the flow.

Data archiving. Storage of data on a set of catalogued files which are held in some backup storage medium and not necessarily permanently online.

Data compatibility. The capacity for two systems to exchange data without having to be altered to do so including making any changes in data formats.

Data processing. Treatment of observational data until they are in a form ready to be used for a specific purpose.

Data quality objectives. Define qualitatively and quantitatively the type, quality and quantity required of primary data and derived parameters to yield information that can be used to support decisions.

Discharge. Volume of water flowing through a river (or channel) cross-section per unit time.

Drainage basin. (See Catchment area)

Elevation. Vertical distance of a point or level, on or affixed to the surface of the ground, measured from mean sea level.

Estuary. Broad portion of a stream near its outlet to a sea, lake or sabkha.

Flood. (1) Rise, usually brief, in the water level of a stream or water body to a peak from which the water level recedes at a slower rate. (2) Relatively high flow as measured by stage height or discharge.

Flood-proofing. Techniques for preventing flood damage in a flood-prone area.

Gauge boards (Staff Gauge). Graduated vertical scale, fixed to a staff or structure, on which the water level may be read.

Gauge datum. Vertical distance between the zero of a gauge and a certain datum level.

Gauging station. Location on a stream where measurements of water level and/or discharge are made systematically.

GAW Station Information System (GAWSIS). The official catalogue for monitoring sites/platforms/stations operating within Global Atmosphere Watch (GAW) as well as related programmes providing station metadata and serving as the clearing house for unique station identifiers. GAWSIS represents the metadata source for OSCAR for GAW observations.

Hydrograph. Graph showing the variation in time of some hydrological data, such as stage, discharge, velocity and sediment load.

Hydrological Forecast. Estimation of the magnitude and time of occurrence of future hydrological events for a specified period and for a specified locality.

Hydrological observation. Direct measurement or evaluation of one or more hydrological elements, such as stage, discharge and water temperature.

Hydrological observing station. Place where hydrological observations or climatological observations for hydrological purposes are made.

Hydrological warning. Emergency information on an expected hydrological event which is considered to be dangerous.

Hydrometric station. Station at which data on water in rivers, lakes or reservoirs are obtained on one or more of the following elements: stage, streamflow, sediment transport and deposition, water temperature and other physical properties of water, characteristics of ice cover and chemical properties of water.

Intercomparison. A formalized process to assess the relative performance of two or more systems (observing, forecasting, etc.)

Moving-Boat Method. Method of measuring discharge which uses a boat to traverse the stream along the measuring section and continuously measure velocity, depth and distance travelled

Quality. The degree to which a set of inherent characteristics fulfils requirements.

Quality Assurance. That part of quality management focused on providing confidence that quality requirements will be fulfilled.

Quality Control. That part of quality management focused on fulfilling quality requirements.

Quality Management. The coordinated activities to direct and control an organization with respect to quality.

Rating curve. Curve showing the relation between stage and discharge of a stream at a hydrometric station.

Recession. Period of decreasing discharge as indicated by the falling limb of a hydrograph starting from the peak.

Registration. Certification is very often referred to as registration in North America.

Reservoir. Body of water, either natural or man-made, used for storage, regulation and control of water resources.

River. Large stream which serves as the natural drainage for a basin.

Stage. See water level.

Stage-discharge relation. Relationship between water level and discharge for a river cross-section, which may be expressed as a curve, a table or an equation.

Streamflow. General term for water flowing in a watercourse.

Uncertainty. Estimate of the range of values within which the true value of a variable lies.

Upstream. Direction from which a fluid is moving.

Verification. The process of establishing the truth, accuracy, or validity of something.

Water level. Elevation of the free water surface of a water body relative to a datum level.

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1. INTRODUCTION TO WIGOS

1.1 Purpose of WIGOS

1.1.1 The WMO Integrated Global Observing System (WIGOS) shall be a framework for all WMO observing systems and the contributions of WMO to co-sponsored observing systems in support of all WMO Programmes and activities.

Note: The co-sponsored observing systems are the WMO-IOC-UNEP-ICSU Global Climate Observing System (GCOS), the WMO-IOC-UNEP-ICSU Global Ocean Observing System (GOOS) and the WMO-IOC-UNEP-ICSU Global Terrestrial Observing System (GTOS).

1.1.2 The WIGOS shall facilitate the use by WMO Members of observations from systems that are owned, Note managed and operated by a diverse array of organizations and programmes.

1.1.3 The principle purpose of WIGOS shall be to meet the evolving requirements of Members for observations.

Note: The promulgation of WIGOS will advance the state of observing systems and data exchange worldwide, with additional benefits emerging as the concept is adopted by entities beyond WMO itself and its partner organizations.

1.1.4 The interoperability (including data compatibility) of WIGOS component observing systems shall be achieved through their common utilization and application of internationally accepted standard and recommended practices and procedures. Data compatibility shall also be supported through the use of data representation standards.

1.2 WIGOS component observing systems

1.2.1 The component observing systems of WIGOS shall comprise the Global Observing System (GOS) of the World Weather Watch (WWW) Programme, the observing component of the Global Atmosphere Watch (GAW) Programme, the WMO Hydrological Observing System (WHOS) of the Hydrology and Water Resources Programme (HWRP) and the observing component of the Global Cryosphere Watch (GCW), including their surface-based and space-based components.

Note: The above component systems include all WMO contributions to the co-sponsored systems, as well as the WMO contributions to the Global Framework for Climate Services (GFCS) and Global Earth Observation System of Systems (GEOSS).

1.2.1 Global Observing System of the World Weather Watch

1.2.1.1 The Global Observing System (GOS) shall be constituted as a coordinated system of observing networks, methods, techniques, facilities and arrangements for making observations on a world-wide scale and defined as one of the main components of the World Weather Watch.

1.2.1.2 The purpose of the Global Observing System shall be to provide the meteorological observations from all parts of the globe that are required by Member countries for operational and research purposes through all WMO and co-sponsored programmes.

1.2.1.3 The Global Observing System shall consist of: (i) a surface-based sub-system composed of regional basic networks of stations and platforms, and other networks of stations and platforms; and (ii) a space-based sub-system composed of: (a) an Earth observation space segment; (b) an associated ground system for data reception, dissemination and stewardship; and (c) a user segment.

1.2.1.4 The Global Observing System shall comply with the provisions specified in the sections 1, 2, 3, 4 and 7 of this Manual.

1.2.2 Global Atmosphere Watch (observing component)

1.2.2.1 The Global Atmosphere Watch (GAW) shall be a coordinated system of observing networks, methods, techniques, facilities and arrangements encompassing the many monitoring

and related scientific assessment activities devoted to the investigation of the chemical composition and related physical characteristics of the atmosphere.

1.2.2.2 The purpose of the Global Atmosphere Watch shall be to provide data and other information on the atmospheric chemical composition and related physical characteristics of the background, unpolluted atmosphere, as defined in section 5 of this Manual, from all parts of the globe, required to reduce environmental risks to society and meet the requirements of environmental conventions, strengthen capabilities to predict the state of climate, weather and air quality, and contribute to scientific assessments in support of environmental policy.

1.2.2.3 The observing component of GAW shall consist of a surface-based system composed of networks for observation of specified variables, complemented by space-based observations.

1.2.3.4 The observing component of the Global Atmosphere Watch Programme shall be operated in accordance with the provisions specified in the sections 1, 2, 3, 4 and 5 of this Manual.

1.2.3 WMO Hydrological Observing System

1.2.3.1 The WMO Hydrological Observing System (WHOS) shall comprise hydrological observations, initially focusing on water level and discharge.

Note: The composition of the WMO hydrological observing systems is provided in the Technical Regulations, Volume III – Hydrology, Chapter D.1.2 of the *WMO Technical Regulations* (WMO-No. 49).

1.2.3.2 The WMO hydrological observing systems shall expand to include other elements identified through the application of the Rolling Review of Requirements (RRR) process (specified in section 2.2.4 and Appendix 2.3 of this Manual) at the national, regional and global levels.

1.2.3.3 The purpose of the WHOS shall be to provide real time stream data (both water level and discharge) from participating Members.

1.2.3.4 Members making their hydrological observations available through the WMO Hydrological Observing System (WHOS) shall comply with the provisions specified in the sections 1, 2, 3, 4 and 8 of this Manual.

Note: Volume III – Hydrology, the *Guide to Hydrological Practices* (WMO-No. 168), and the *Manual on Stream Gauging* (WMO-No. 1044) and the *Manual on Flood Forecasting and Warning* (WMO-No. 1072) provide the necessary information to operate hydrological stations to prescribed standards.

1.2.4 Global Cryosphere Watch (observing component)

1.2.4.1 The Global Cryosphere Watch (GCW) shall be a coordinated system of observing networks, methods, techniques, facilities and arrangements encompassing monitoring and related scientific assessment activities devoted to the investigation of the Cryosphere.

1.2.4.2 The purpose of the Global Cryosphere Watch shall be to provide data and other information on the cryosphere, from a local to the global scale, to improve understanding of its behaviour, interactions with other components of the climate system, and impacts on society.

1.2.4.3 The GCW observing network and its standardized core network (CryoNet) shall build on existing observing programmes and promote the addition of standardized cryospheric observations to existing facilities.

1.2.4.4 The observing component of the Global Cryosphere Watch shall comply with the provisions specified in the sections 1, 2, 3, 4 and 6 of this Manual.

1.3 Governance and management

1.3.1 Implementation and Operation of WIGOS

1.3.1.1 Members shall be responsible for all activities connected with the implementation and operation of WIGOS on the territories of their individual countries.

1.3.1.2 Members should, as far as possible, use national resources for the implementation and operation of WIGOS, but, where necessary and so requested, assistance may be provided in part through:

(a) The WMO Voluntary Cooperation Programme (VCP);

(b) Other bilateral or multilateral arrangements including the United Nations Development Programme (UNDP) which should be used to the maximum extent possible.

1.3.1.3 Members should participate voluntarily in the implementation and operation of WIGOS in regions outside the territories of individual countries (e.g. outer space, oceans, the Antarctic), if they desire and are able to contribute by providing facilities and services, either individually or jointly.

1.3.2 WIGOS Quality Management

Note 1: Provisions relating to the WMO Quality Management Framework, WMO QMF, are provided the *Technical Regulations* (WMO-No. 49), Volume IV – Quality Management, 2011 edition).

Note 2: Within the WMO Quality Management Framework, WIGOS provides the procedures and practices with regard to the quality of observations and observational metadata that should be adopted by Members in establishing their quality management system for the provision of meteorological, hydrological, climatological and other related environmental observations.

Note 3: Section 2.6 of this Manual provides detailed provisions on WIGOS Quality Management.

1.3.3 WIGOS high level processes

1.3.3.1 Members should adopt a process-based approach to the management of WIGOS observing systems as described in Attachment 1 to this section.

ATTACHMENT 1

WIGOS high level processes

Many of the WIGOS activities may be represented together as a series of high level processes.

Figure 1 provides a schematic description of the processes (horizontal bars), the collaborating entities (vertical columns) and those having primary involvement in each process (marked by solid circles). In reality the processes have more complex interrelationships and sequences than shown by the arrows – the most extreme case is the capacity development (including training) process which is not shown as a step in the sequence since it has important inputs to most of the other processes.

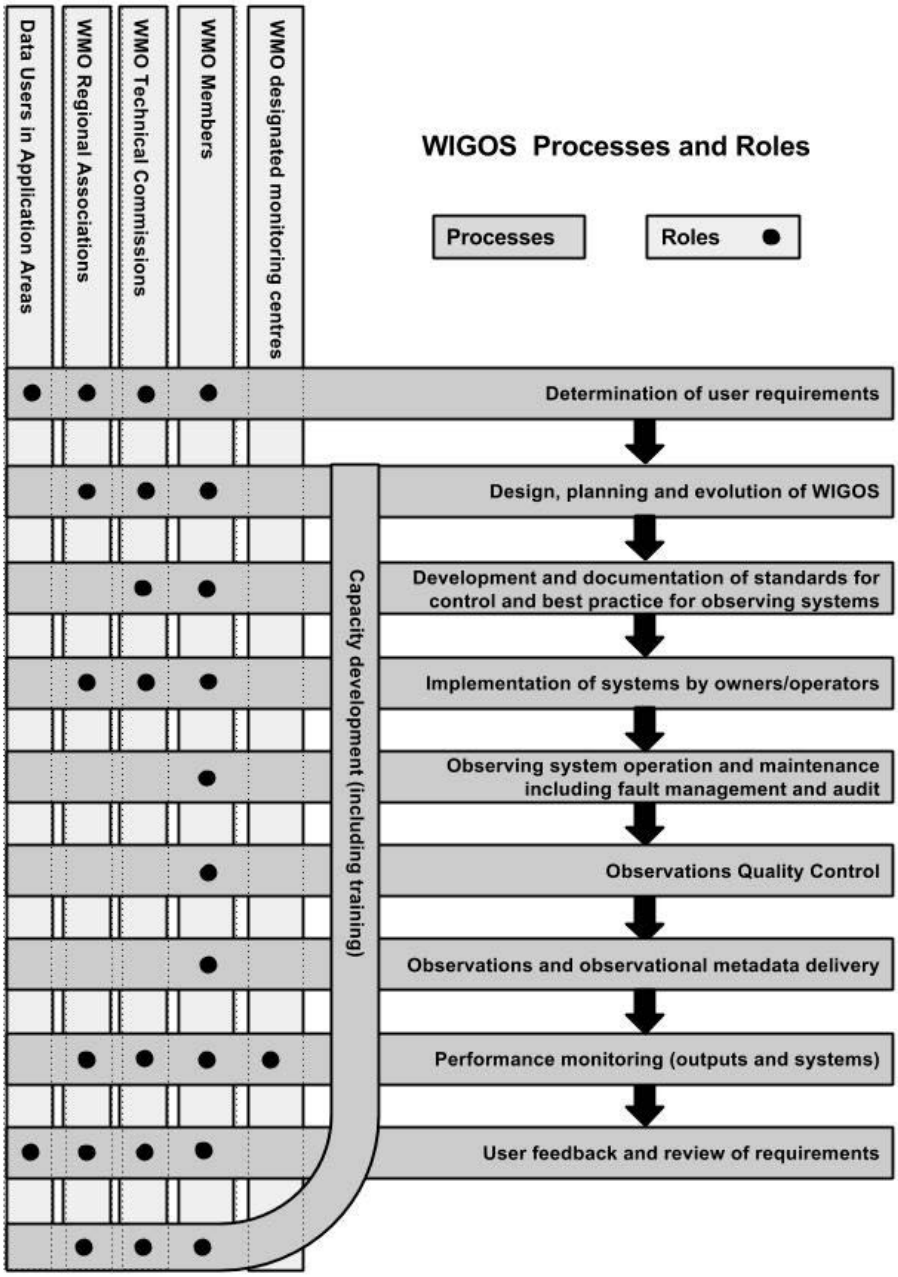

FIGURE 1: Schematic diagram of WIGOS high-level processes (horizontal bars), the collaborating entities (vertical columns) and those having primary involvement in each process (marked by solid circles).

These processes are carried out by Members through one of the following modes of collaboration:

- Data Users in Application Areas: Members collaborate by selectively contributing Application experts and information to provide the capability to undertake the relevant WIGOS process(es),
- WMO regional associations: Members collaborate by working together in a geographical grouping, and by selectively contributing experts for regional teams, to undertake the relevant WIGOS process(es),
- WMO technical commissions: Members collaborate by selectively contributing technical experts for global teams to undertake the relevant WIGOS process(es),
- WMO Members: as individual operators and managers of observing systems, Members directly undertake the relevant WIGOS process(es),
- WMO designated Centres for performance monitoring (including Lead Centres, and Monitoring Centres): individual Members or groups of Members operate a WMO centre designated for performance monitoring, including Lead Centres or Monitoring Centres, to undertake the relevant WIGOS process(es).

In the case of WIGOS processes being undertaken by the WMO Secretariat or other entities funded by WMO Programmes, the mode of collaboration is through the overall operation of the WMO.

The following example illustrates the relation between the WIGOS high-level processes and the structure of the regulatory material. In section 2 of this Manual the standard and recommended practices and procedures relevant to each WIGOS process can be found in the following sub-sections of this Manual:

- Determination of user requirements: 2.1, 2.2
- Design, planning and evolution of WIGOS: 2.2
- Development and documentation of standard and recommended practices and procedures for observing systems: 2.3
- Implementation of observing system by owners and operators: 2.3, 2.4
- Observing system operation and maintenance including fault management and audit: 2.4
- Observation quality control: 2.4, 2.6
- Observations and observational metadata delivery: 2.4, 2.5
- Performance monitoring: 2.4, 2.6
- User feedback and review of requirements: 2.2, 2.6
- Capacity development (including training): 2.7

2. COMMON ATTRIBUTES OF WIGOS COMPONENT SYSTEMS

2.1 Requirements

2.1.1 Members shall take steps for collecting, recording, reviewing, updating, and making available their observational user requirements.

2.1.2 Members shall convey their observational user requirements, for each of the WMO application areas, to the Rolling Review of Requirements (RRR) process specified under 2.2.4 and Appendix 2.3.

2.2 Design, planning and evolution

2.2.1 General

2.2.1.1 The WIGOS shall be designed as a flexible and evolving system capable of continuous improvement.

Note: Factors which drive the evolution of WIGOS component observing systems include technological and scientific progress and cost-effectiveness, changes in the needs and requirements of WMO, WMO co-sponsored programmes and international partner organizations at national, regional and global levels, and changes in the capacity of Members to implement observing systems. It is important to identify the impact on all users before a change is made.

2.2.1.2 Members shall plan and operate their networks in a sustainable and reliable manner utilizing WIGOS standard and recommended practices and procedures, and tools.

Note: Sustainability over at least a ten year period is recommended; however, this depends on paying sufficient attention to maintenance and operations following the original establishment.

2.2.2 Some Principles for Observing System Network Design and Planning

2.2.2.1 Observing System Network Design Principles

2.2.2.1.1 Members should follow the principles specified in Appendix 2.1 to this section when designing and evolving their observing system networks.

2.2.2.1.2 Members should conduct network design studies which address national, regional and global scale questions about the optimum affordable mix of components to best satisfy the requirements for observations.

2.2.2.2 GCOS Climate Monitoring Principles

2.2.2.2.1 Members designing and operating observing systems for monitoring climate should adhere to the principles specified in Appendix 2.2.

Note: Fifty Essential Climate Variables (ECVs) have been identified for GCOS, which are required to support the work of the United Nations Framework Convention on Climate Change (UNFCCC) and the Inter-governmental Panel on Climate Change (IPCC). The ECVs cover the atmospheric, oceanic and terrestrial domains, and all are technically and economically feasible for systematic observation. Further information about the ECVs is in the "Implementation Plan for the Global Observing System for Climate in support of the UNFCCC (2010 Update)" (GCOS-138, also identified as WMO-TD/No.1523).

2.2.3 Vision for WIGOS observing systems

2.2.3.1 Members shall take into account the "*Vision for the global observing system in 2025"* when planning the evolution of their observing networks.

Note 1: The "*Vision for the global observing system in 2025*" provides high-level goals to guide the evolution of the WMO integrated global observing systems in the coming decades. The Vision is updated on a multi-year time scale (typically decadal).

Note 2: The "*Vision for the global observing system in 2025*" is available at: http://www.wmo.int/pages/prog/www/OSY/gos-vision.html

2.2.4 The Rolling Review of Requirements (RRR) Process

2.2.4.1 Members, both directly and through the participation of their experts in the activities of regional associations and technical commissions, shall contribute to the Rolling Review of

Requirements (RRR) process and assist the designated Points of Contact (PoCs) for each Application Area in performing their roles in the RRR.

Note: Appendix 2.3 to this section provides further details on the RRR process.

2.2.5 Observation Impact studies

2.2.5.1 Members, or groups of Members within regions, should conduct and/or participate in observation impact studies and related scientific evaluations to address WIGOS network design questions.

2.2.5.2 Members should provide expertise for synthesizing the results of impact studies and making recommendations on the best mix of observing systems to address the gaps identified by the RRR process.

Note: Impact studies using Observing System Experiments (OSEs), Observing System Simulation Experiments (OSSEs), Forecast Sensitivity to Observations (FSO) studies and other assessment tools are used to assess the impact of the various observing systems on Numerical Weather Prediction model analyses and predictions, hence their value and relative priority for addition or retention for these Application Areas.

2.2.6 Evolution of WIGOS observing systems

2.2.6.1 Members should follow the plans published by WMO for evolution of WIGOS component observing systems when planning and managing their WIGOS observing systems.

Note 1: The planning and coordination of the evolution of WIGOS observing systems is steered by the Executive Council and undertaken by Members individually and through regional associations, technical commissions and relevant steering bodies of WMO co-sponsored observing systems.

Note 2: The current WMO plan for the evolution of WIGOS observing systems was published as the "*Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP)*" (WIGOS Technical Report No. 2013-4). It contains guidelines and recommended actions to be undertaken by Members, technical commissions, regional associations, and satellite operators and other relevant parties in order to stimulate cost-effective evolution of the WMO observing systems to address in an integrated way the requirements of WMO Programmes and co-sponsored programmes.

Note 3: The WMO plan for the evolution of WIGOS observing systems is regularly updated and new versions are published on a multi-year time scale (typically decadal), taking into account the Vision for the WIGOS observing systems, and the advice of technical commissions and regional associations, concerned and relevant WMO co-sponsored observing systems, and international experts in all application areas.

2.2.3.6.2 Members shall coordinate the activities by agencies within their country including the National Meteorological and Hydrological Services (NMHSs) and other relevant agencies, in addressing relevant actions of the WMO plans for evolution of WIGOS observing systems.

2.2.3.6.3 In the cases where Member countries cover small areas and are geographically close or already have established multilateral working relationships, Members should consider a sub-regional or transboundary river basin approach, in addition to national, to WIGOS observing systems planning.

2.2.3.6.4 In this case, Members concerned should work in close cooperation to prepare sub-regional or transboundary river basin reviews of requirements to be used as a basis for detailed planning at that scale.

2.2.6.1 Monitoring the evolution of WIGOS observing systems

2.2.6.1.1 Members should contribute to the monitoring of the evolution of WIGOS observing systems by providing their national progress reports on a yearly basis through nominated national focal points.

Note: The Commission for Basic Systems, in collaboration with other technical commissions, regional associations, and co-sponsored programmes, regularly reviews progress of actions of the plan for evolution of WIGOS observing systems, and provides updated guidance to Members regarding the evolution of global observing systems.

APPENDIX 2.1

Observing System Network Design (OSND) Principles

1. SERVING MANY APPLICATION AREAS
Observing networks should be designed to meet the requirements of multiple application areas within WMO and WMO co-sponsored programmes.

2. RESPONDING TO USER REQUIREMENTS
Observing networks should be designed to address stated user requirements, in terms of the geophysical variables to be observed and the space-time resolution, uncertainty, timeliness and stability needed.

3. MEETING NATIONAL, REGIONAL AND GLOBAL REQUIREMENTS
Observing networks designed to meet national needs should also take into account the needs of the WMO at the regional and global levels.

4. DESIGNING APPROPRIATELY SPACED NETWORKS
Where high-level user requirements imply a need for spatial and temporal uniformity of observations, network design should also take account of other user requirements, such as the representativeness and usefulness of the observations.

5. DESIGNING COST-EFFECTIVE NETWORKS
Observing networks should be designed to make the most cost-effective use of available resources. This will include the use of composite observing networks.

6. ACHIEVING HOMOGENEITY IN OBSERVATIONAL DATA
Observing networks should be designed so that the level of homogeneity of the delivered observational data meets the needs of the intended applications.

7. DESIGNING THROUGH A TIERED APPROACH
Observing network design should use a tiered structure, through which information from reference observations of high quality can be transferred to and used to improve the quality and utility of other observations.

8. DESIGNING RELIABLE AND STABLE NETWORKS
Observing networks should be designed to be reliable and stable.

9. MAKING OBSERVATIONAL DATA AVAILABLE
Observing networks should be designed and should evolve in such a way as to ensure that the observations are made available to other WMO Members, at space-time resolutions and with a timeliness to meet the needs of regional and global applications.

10. PROVIDING INFORMATION SO THAT THE OBSERVATIONS CAN BE INTERPRETED
Observing networks should be designed and operated in such a way that the details and history of instruments, their environments and operating conditions, their data processing procedures and other factors pertinent to the understanding and interpretation of the observational data (i.e. metadata) are documented and treated with the same care as the data themselves.

11. ACHIEVING SUSTAINABLE NETWORKS
Improvements in sustained availability of observations should be promoted through the design and funding of networks that are sustainable in the long-term including, where appropriate, through the transition of research systems to operational status.

12. MANAGING CHANGE
The design of new observing networks and changes to existing networks should ensure adequate consistency, quality and continuity of observations across the transition from the old system to the new.

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APPENDIX 2.2

GCOS Climate Monitoring Principles

Effective monitoring systems for climate should adhere to the following principles:

1. The impact of new systems or changes to existing systems should be assessed prior to implementation;
2. A suitable period of overlap for new and old observing systems is required;
3. The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e., metadata) should be documented and treated with the same care as the data themselves;
4. The quality and homogeneity of data should be regularly assessed as a part of routine operations;
5. Consideration of the needs for environmental and climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional and global observing priorities;
6. Operation of historically-uninterrupted stations and observing systems should be maintained;
7. High priority for additional observations should be focused on data-poor regions, poorly observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution;
8. Long-term requirements, including appropriate sampling frequencies, should be specified to network designers, operators and instrument engineers at the outset of system design and implementation;
9. The conversion of research observing systems to long-term operations in a carefully-planned manner should be promoted;
10. Data management systems that facilitate access, use and interpretation of data and products should be included as essential elements of climate monitoring systems;

Furthermore, operators of satellite systems for monitoring climate need to:

(a) Take steps to make radiance calibration, calibration-monitoring and satellite-to-satellite cross-calibration of the full operational constellation a part of the operational satellite system; and

(b) Take steps to sample the Earth system in such a way that climate-relevant (diurnal, seasonal, and long-term interannual) changes can be resolved.

Thus satellite systems for climate monitoring should adhere to the following specific principles:

11. Constant sampling within the diurnal cycle (minimizing the effects of orbital decay and orbit drift) should be maintained;
12. A suitable period of overlap for new and old satellite systems should be ensured for a period adequate to determine inter-satellite biases and maintain the homogeneity and consistency of time-series observations;
13. Continuity of satellite measurements (i.e. elimination of gaps in the long-term record) through appropriate launch and orbital strategies should be ensured;
14. Rigorous pre-launch instrument characterization and calibration, including radiance confirmation against an international radiance scale provided by a national metrology institute, should be ensured;

15. On-board calibration adequate for climate system observations should be ensured and associated instrument characteristics monitored;

16. Operational production of priority climate products should be sustained and peer-reviewed new products should be introduced as appropriate;

17. Data systems needed to facilitate user access to climate products, metadata and raw data, including key data for delayed-mode analysis, should be established and maintained;

18. Use of functioning baseline instruments that meet the calibration and stability requirements stated above should be maintained for as long as possible, even when these exist on decommissioned satellites;

19. Complementary in situ baseline observations for satellite measurements should be maintained through appropriate activities and cooperation;

20. Random errors and time-dependent biases in satellite observations and derived products should be identified;

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APPENDIX 2.3

The RRR Process

The WMO Rolling Review of Requirements (RRR) process compiles information on Members evolving requirements for observations in the application areas that directly use observations; the extent to which current and planned WIGOS observing systems satisfy those requirements; guidance from experts in each application area on the gaps and the priorities for addressing the deficiencies and opportunities in WMO observing systems; and hence plans for the future evolution of WIGOS observing systems.

The Application Areas are:

- Global numerical weather prediction (GNWP);
- High-resolution numerical weather prediction (HRNWP);
- Nowcasting and very short range forecasting (NVSRF);
- Seasonal and inter-annual forecasting (SIAF);
- Aeronautical meteorology;
- Atmospheric chemistry;
- Ocean applications;
- Agricultural meteorology;
- Hydrology;
- Climate monitoring (as undertaken through the Global Climate Observing System, GCOS);
- Climate applications;
- Space weather.

Note: A detailed and up-to-date description of the RRR process is available on the WMO website at http://www.wmo.int/pages/prog/www/OSY/GOS-RRR.html.

In addition, observational requirements for WMO polar activities and the Global Framework for Climate Services (GFCS) are also being considered. The observational needs of the former application area "Synoptic meteorology" are now captured and reviewed along with those for NVSRF.

An expert is identified for each Application Area to be the Point of Contact (PoCs). That expert has a very important role as the conduit to the RRR for input and feedback from the entire stakeholder community for that Application Area.

The nominated Point of Contact should coordinate with their Application Area community (technical commission, or programme or co-sponsored programme as appropriate) as needed in order to perform the following tasks:

(1) Investigate whether it is appropriate to represent the Application Area in several sub-applications;

(2) Submit the quantitative observational user requirements to the OSCAR/Requirements database (see www.wmo.int/oscar), review and keep up-to-date these requirements, and make changes as needed (the PoCs are provided with the required access rights);

(3) Produce, review and revise the Statement of Guidance for the Application Area;

(4) Review how requirements for cross-cutting activities (e.g. Cryosphere, climate services) are taken into account in the user requirements database and in the SoG for the Application Area.

Note: The observational user requirements compiled through the RRR process are stored and made available by the WIGOS Operational Information Resource (WIR) (OSCAR/Requirements database) as described in detail in Attachment 2.2 to this section.

The RRR process consists of four stages:

(1) A review of technology-free (that is, not constrained by any particular type of observing technology) users requirements for observations, within each of the WMO Application Areas (see section 2.1 of this Manual);

(2) A review of the observing capabilities of existing and planned observing systems, both surface- and space-based;

(3) A Critical Review, a comparison of requirements with the observing system capabilities; and

(4) A Statement of Guidance providing a gap analysis with recommendations on addressing the gaps for each Application Area.

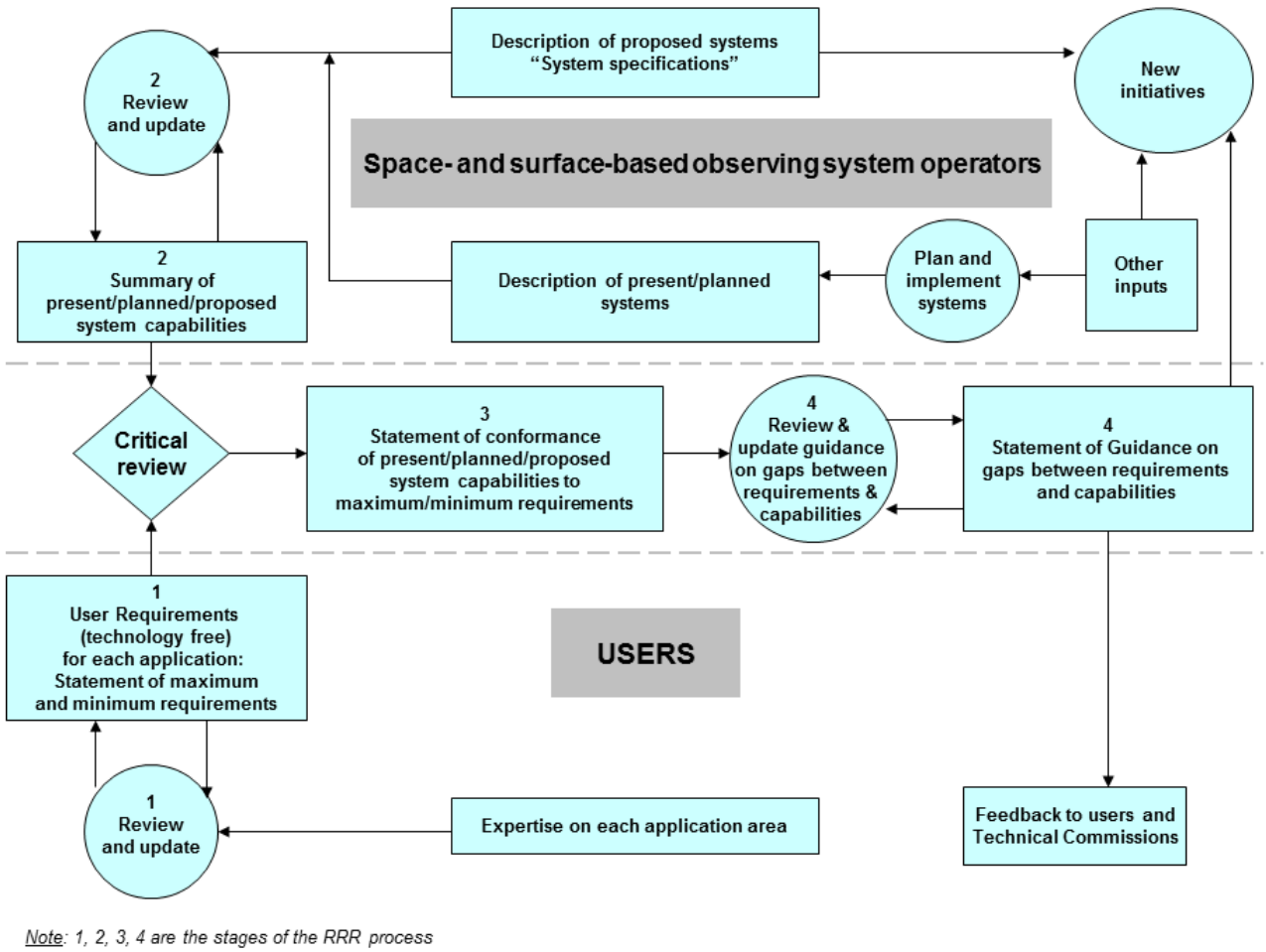

Figure 2: Schematic representation of the steps included in the Rolling Review of Requirements process.

1) Review of observational user requirements

Note 1: This stage of the RRR is described briefly in section 2.1 of this Manual.

Note 2: Regional associations examine and provide to PoCs additional detail for the compiled user requirements, taking into account the particular requirements of the Region and transboundary river basin authorities.

2) Review of current and planned observing systems capabilities

Members shall take steps for collecting, reviewing, recording, and making available current and planned capabilities of observing systems.

Note: Information on observing system capabilities is in the form of metadata and is to be made available for global compilation according to the provisions of section 2.5 of this Manual.

3) The critical review

Note: This WMO Programme activity proceeds with assistance from the PoCs of the Application Areas. It compares the quantitative observational user requirements of each Application Area with the observing systems capabilities.

4) Statements of Guidance

Note 1: The Statement of Guidance interprets the output of the critical review as a gap analysis and identifies priorities for action – the most feasible, beneficial and affordable initiatives to close the identified gaps or shortcomings in WMO observing systems for an Application Area. This draws on the subjective judgement and experience of the PoC and all of the experts and other stakeholders they consult within their Application Area.

Note 2: This stage of the RRR requires the Application Area PoCs to coordinate with their Application Area community and stakeholders as needed in order to produce, review and revise the Statement of Guidance for the Application Area.

2.3 Instrumentation and Methods of Observation

Note 1: Provision 2.3.1, Volume I, Part I applies.

Note 2: Further details are provided in the *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), *Weather Reporting* (WMO-No. 9), Volume D – Information for Shipping, and the *Guide to Hydrological Practices* (WMO-No. 168), Volume I: Hydrology – From Measurement to Hydrological Information.

2.3.1.1 Members should ensure that observations and observational metadata are traceable to International Standards (SI), where these exist.

Note: Traceability to International Standards (SI) is an area where concerted effort is required to increase-improve compliance.

2.3.1.2 Members should employ properly calibrated instruments and sensors that provide observations satisfying at least measurement uncertainties that meet the specified requirements.

Note 1: Achievable measurement uncertainty is specified in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1 (1.6.5.2), Annex 1.D.

Note 2: A number of operational, financial, environmental and instrumental issues may cause the system to not always satisfy the specified requirements, e. g. Annex 1.D (the column „achievable“) provides a list of the achievable and affordable measurement uncertainties which in some cases might not satisfy specified requirements.

2.3.1.3 Members should describe uncertainty of observations and observational metadata as specified in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1 (1.6).

Note 1: The corresponding text from the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1 (1.6) will be included as an Appendix to this section in a future edition.

Note 2: The definition of uncertainty in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter1 (1.6) is consistent with international standards approved by the International Committee for Weights and Measures (CIPM).

2.3.1.4 Members should follow the definitions and specifications for the calculation of derived observations specified in the WMO Technical Regulations and further consider methods provided or referenced by the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) and the *Guide to Hydrological Practices* (WMO-No. 168), Volume I: Hydrology – From Measurement to Hydrological Information.

Note 1: Such derivations can take many forms, such a statistical processing of average or smooth values, or multivariate algorithm to determine streamflow discharge.

Note 2: The corresponding text from the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), will be included as an Appendix to this section in a future edition.

2.4 Operations

2.4.1 General Requirements

Note: Provision 2.4.1.1, Volume I, Part I applies.

2.4.1.1 WMO observing stations and platforms shall be uniquely identified by a WIGOS station identifier.

Note: The structure of WIGOS station identifiers is specified in Attachment 2.1

2.4.1.2 Members shall issue WIGOS station identifiers for observing stations and platforms within their geographic area of responsibility that contribute to a WMO or co-sponsored programme and shall ensure that no WIGOS station identifier is issued to more than one station.

Note: Members may issue WIGOS station identifiers for observing stations and platforms within their geographic area of responsibility that do not contribute to a WMO or co-sponsored programme, provided that the operator has committed to providing and maintaining WIGOS metadata.

2.4.1.3 Before issuing a station identifier, Members should ensure that the operator of a station or platform has committed to providing and maintaining WIGOS metadata for that station or platform and to conforming to relevant Technical Regulations.

Note 1: In circumstances when a WIGOS identifier is required for a station or platform to support a WMO or co-sponsored programme and no Member is in a position to issue one (e.g. Antarctica), the Secretary-General may issue a WIGOS station identifier for that station or platform provided that its operator has committed to:

(a) Providing WIGOS metadata; and

(b) Conforming to relevant Technical Regulations.

Note 2: In circumstances where a WIGOS identifier is required for a station or platform to support a WMO or co-sponsored programme and a Member is not able to issue a WIGOS identifier, the Secretary-General will work with the Member concerned to issue a WIGOS station identifier for that station or platform provided that its operator has committed to:

(a) Providing WIGOS metadata; and

(b) Conforming to relevant Technical Regulations.

2.4.1.4 Members shall make available to WMO the updated metadata each time a new station identifier is issued.

2.4.1.5 Members shall operate their observing systems with properly calibrated instruments and adequate observing and measuring techniques.

Note 1: Detailed guidance on observing practices of meteorological observing systems and instruments is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8).

Note 2: Detailed guidance on observing practices of hydrological observing systems and instruments is given in the *Guide to Hydrological Practices* (WMO-No. 168); the *Manual on Flood Forecasting and Warning* (WMO-No. 1072), and the *Manual on Stream Gauging* (WMO-No. 519).

Note 3: Detailed guidance on observing practices of GAW observing systems and instruments is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8).

2.4.1.6 Members should address the requirements for uncertainty, timeliness, temporal resolution, spatial resolution, and coverage which result from the RRR process specified in section 2.2.4 of this Manual and in accordance with the details provided by other sections of this Manual as appropriate.

2.4.1.7 Members shall publish a handbook of national safety practices and procedures for operation of the observing systems that stresses precautions and practices specific to the conditions in the country concerned and satisfies country specific requirements regarding legal, health and safety codes.

Note: Safety practices and procedures are those that are concerned with assuring the welfare of staff while promoting overall efficiency and effectiveness of the NMHS and responding to national laws, regulations and requirements for occupational health and safety.

2.4.2 Observing Practices

2.4.2.1 Members should ensure that their observing practices are adequate to comply with the observational user requirements.

Note: Observing practices is inclusive of station operation, data processing practices and procedures, applied calculation rules, documentation on calibration practices and associated metadata.

2.4.3 Quality Control

2.4.3.1 Members shall ensure observations provided through their WIGOS component observing systems are quality controlled.

2.4.3.2 Members shall implement real-time quality control prior to exchange of observations via the WMO Information System.

Note 1: Quality control of observations consists of examination of observations at stations and at data centres to detect errors so that observations may be either corrected or flagged. A quality control system should include procedures for returning to the source of observations to verify them and to prevent recurrence of errors. Quality control is applied in real time, but it also operates in non real-time, as delayed quality control. Observations quality depends on the quality control procedures applied during observations acquisition and processing and during preparation of messages, in order to eliminate the main sources of errors and ensure the highest possible standard of accuracy for the optimum use of these observations by all possible users.

Notes 2: Quality control on a real-time basis also takes place in the Global Data-Processing and Forecasting System, prior to the use of the meteorological and climatological observations in data processing (i.e. objective analysis and forecasting).

Note 3: Recommended minimum standards of quality control of the meteorological and climatological observations at the level of the National Meteorological Centre are given in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), Volume I – Global Aspects, Appendix II-1, Table I. The *Guide on the Global Data-processing System* (WMO-No. 305) should be consulted for more detailed guidance.

Note 4: Recommended practices and procedures for quality control of hydrological observations are given in the *Manual on Flood Forecasting and Warning* (WMO-No. 1072), Chapter 6 and the *Guide to Hydrological Practices* (WMO-No. 168).

Note 5: Recommended practices and procedures regarding the quality of observations for GAW requirements are formulated in Measurement Guidelines through Data Quality Objectives.

2.4.3.3 Members not capable of implementing these standards should establish agreements with an appropriate Regional Meteorological Centre or World Meteorological Centre to perform the necessary quality control.

2.4.3.4 Members shall also perform quality control of observations on a non-real-time basis, prior to forwarding the observations for archiving.

2.4.3.5 Members should develop and implement adequate quality control processes.

Note 1: Quality control processes include (but are not necessarily limited to): (a) validation; (b) cleaning; (c) monitoring.

Note 2: Further guidance is available in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), *Guide to Climatological Practices* (WMO-No. 100), *Guide to Hydrological Practices* (WMO-No. 168), Volume I: Hydrology – From Measurement to Hydrological Information, and *Guide to the Global Observing System* (WMO-No. 488).

2.4.3.6 Members shall inform the Secretary-General (for general dissemination) of any special features of their observing systems which may be important in the correct interpretation of the data provided.

2.4.4 Data and Metadata Reporting

2.4.4.1 Members shall report and make available observations in standard formats specified by the *Manual on Codes* (WMO-No. 306)).

2.4.4.2 In the case of GAW observations, Members shall report and make available observations in standard formats as advised by GAW data centres, in accordance with the provisions in section 5 of this Manual.

Note: Members are to report and make available up-to-date WIGOS metadata as specified in section 2.5.2 of this Manual.

2.4.5 Incident Management

2.4.5.1 Members should implement incident management to detect, identify, record, analyze and respond to any incident for restoring a normal observing system operation as quickly as possible, minimizing the negative impact, and preventing a future re-occurrence.

2.4.5.2 Members shall implement procedures to detect, analyze and respond to system faults and human errors at the earliest stage possible.

2.4.5.3 Members should record and analyze incidents as appropriate.

2.4.6 Change Management

2.4.6.1 Members should carefully plan and control changes to ensure continuity and consistency of observations and record any modification related to the observing system.

Note: This requirement relates to any change in the observing system, including an observing station, observing programme, instruments, methods of observation, etc.

2.4.6.2 In the case of significant changes in instruments or methods of observation used or the location in which observations are made, Members should ensure a sufficiently long period (to capture all expected climatic conditions) of overlap with dual operation of old and new systems to identify biases, inconsistencies and inhomogeneities.

2.4.7 Maintenance

2.4.7.1 Members shall ensure that each observing system is rigorously maintained.

2.4.7.2 Members shall perform regular preventive maintenance of their observing systems including their instruments.

Note: Carefully organized preventive maintenance of all system components is recommended to minimize corrective maintenance and to increase the operational reliability of an observing system.

2.4.7.3 Members shall determine the frequency and timing (schedule) of the preventive maintenance taking into account the type of the observing system, environmental and climate conditions of the observing site and platform, and the instrumentation installed.

2.4.7.4 Members shall perform corrective maintenance in case of observing system component fault as soon as practically possible once the problem has been detected.

2.4.7.5 Members shall employ adaptive maintenance that satisfies the requirements for stability, continuity and consistency of observations through time.

Note: Detailed guidance on maintenance of observing systems and instruments is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) including all of the GAW measurement guides as referenced in Chapter 16 of the Guide, the *Guide to Hydrological Practices* (WMO-No. 168) and the *Manual on Stream Gauging* (WMO-No. 1044).

2.4.8 Inspection

2.4.8.1 Members shall arrange periodic inspection of their observing systems.

Note: Such inspection could be undertaken directly or remotely as necessary to monitor correct functioning of observing platform and instruments.

2.4.9 Calibration procedures

2.4.9.1 Members shall ensure that measurement systems and instruments are calibrated regularly in accordance with adequate procedures for each type of system and instrument, as described in the relevant sections of this Manual.

Note 1: Where international or national standards are not available, the basis for calibration is defined or supplied by the manufacturer or by the Scientific Advisory Groups for GAW observations.

Note 2: Detailed guidance on calibration procedures is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), the *Guide to Hydrological Practices* (WMO-No. 168) and the *Manual on Stream Gauging* (WMO-No. 1044).

Note 3: In the GAW Programme, World Calibration Centres perform the audit of the stations and require that every laboratory is traceable to the single network standard.

2.4.9.2 Members shall ensure that the measuring devices they use are:

(a) Calibrated or verified at specified intervals, or prior to use, against measurement standards traceable to international or national measurement standards. Where no such standards exist, the basis used for calibration or verification shall be recorded.

(b) Adjusted or readjusted as necessary, but at the same time safeguarded from adjustments that would invalidate the measurements;

(c) Identified, enabling the calibration status to be determined; and

(d) Protected from damage and deterioration during handling, maintenance and storage.

Note: Details regarding the hydrological observations are given in the WMO *Technical Regulations* (WMO WMO-No. 49), Volume III – Hydrology; guidance is available in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), the *Guide to Hydrological Practices* (WMO-No. 168) and the *Manual on Stream Gauging* (WMO-No. 1044).

2.4.9.3 When the equipment is found not to conform to requirements, the Member shall assess and record the validity of previous measuring results, and take appropriate action on the equipment and the products affected.

2.4.9.4 Members shall record and maintain the results of calibration and verification.

ATTACHMENT 2.1

Structure of WIGOS Station Identifiers

The structure of the WIGOS Identifier is shown in Figure 1. The meaning of the components of the WIGOS identifier is given in Table 1.

WIGOS Identifier series	Issuer of Identifier	Issue Number	Local Identifier

Figure 1. Structure of WIGOS identifier

Table 1. Allocating the component parts of a WIGOS station identifier

Component	Description	Initial Range – series 0 (Stations) See Note 1	Initial Range – series 1 (Instruments) See Note 1
WIGOS Identifier Series	This is used to distinguish between different systems for allocating identifiers. It allows future expansion of the system so that entities do not have to be issued with new identifiers if the structure of the WIGOS identifiers proves unable to meet future requirements. Different values of the WIGOS Identifier Series may correspond to different structures of the WIGOS identifier. Initial permitted range: 0–14	0	1
Issuer of Identifier	A number that is used to distinguish between identifiers issued by different organizations. It is allocated by WMO to ensure that only one organization can create a given WIGOS station identifier.	0–65534	0–65534 See Note 2
Issue Number	An identifier that an organization responsible for issuing an identifier may use to ensure global uniqueness of its identifiers. For example, allocating one issue number for hydrological stations and another for voluntary climate observing stations would enable the managers of the two networks to issue Local Identifiers independently without needing to check with each other that they were not duplicating identifiers.	0–65534	0–65534 See Note 3
Local Identifier	This is the individual identifier issued for each entity. An organization issuing identifiers must ensure that the combination of Issue Number and Local Identifier is unique; in that way global uniqueness is guaranteed.	16 characters	16 characters See Note 4

Notes:

(1) Although the table proposes initial ranges of permitted values of the components that make up a WIGOS identifier, future changes in requirements may result in these ranges being increased. IT systems must, therefore, be designed to process identifiers whose components are of arbitrary length. BUFR encodings will need to be prepared for WIGOS identifiers to allow efficient representation and these may use code lists to represent components of the WIGOS identifier that are shared by many entities. Currently, station identifier = 0, instrument identifier = 1.

(2) For instruments, the “Issuer of Identifier” corresponds to the manufacturer of the instrument.

(3) For instruments, the “Issue Number” corresponds to the manufacturer’s model identifier for the instrument.

(4) For instruments, the “Local Identifier” corresponds to the manufacturer’s serial number/identifier of the instrument.

Notation for the WIGOS identifier

The convention for writing the WIGOS identifier (in the context of WIGOS) is:

<WIGOS Identifier series>-<Issuer of Identifier>-<Issue Number>-<Local Identifier>

Note: as an example the WIGOS Identifier

WIGOS Identifier series	Issuer of Identifier	Issue Number	Local Identifier
0	513	215	5678

would be written as 0-513-215-5678.

Representing the WIGOS identifier in contexts outside WIGOS

The following conventions should be used to represent the WIGOS identifier in contexts outside WIGOS or to show the relationship between the WIGOS identifier and an identifier that has been defined in a different context.

int.wmo.wigos	WIGOS identifier	WIGOS supplementary identifier

Figure 2. Structure of an extended WIGOS identifier. Both the int.wmo.wigos and the WIGOS supplementary identifier elements are optional.

int.wmo.wigos

The first component of the extended WIGOS identifier (int.wmo.wigos) allows the identifier to be recognized as a WIGOS identifier when used in contexts where it may be ambiguous as to what type of identifier is being used. This is optional and need not be represented in BUFR, because the entries for the WIGOS identifier provide this information.

WIGOS *identifier*

The second component (WIGOS identifier) is defined above. Within a WIGOS context it is the only component of the WIGOS identifier that is always required.

WIGOS supplementary identifier

The final component of the extended WIGOS identifier (WIGOS supplementary identifier) is optional and is used to associate identifiers issued using other systems to be associated with the WIGOS unique identifier. A single WIGOS identifier may be associated with many WIGOS supplementary identifiers (such as an observing site that is used for both synoptic and aviation reporting), and a WIGOS supplementary identifier may be associated with many WIGOS unique identifiers (such as a World Weather Watch drifting buoy identifier that has been issued to many drifting buoys). In BUFR, this would be specified through a specific table entry (such as IIiii for World Weather Watch station identifier).

Note: if above example of a WIGOS identifier (0-513-215-5678) was also associated with an identifier (MYLOCATION) issued by another authority, a valid extended WIGOS identifier would be int.wmo.wigos-0-513-215-5678-MYLOCATION.

2.5. Observational Metadata

2.5.1 Purpose and scope

Note 1: Observational metadata are essential as they enable users of observations to assess their suitability for the intended application and managers of observing systems to monitor and control their systems and networks. WMO Members benefit from sharing observational metadata which describe quality of observations and provide information about stations and networks used to collect those observations.

Note 2: Discovery metadata, defined in the *Manual on the WMO Information System* (WMO-No. 1060), are concerned with discovering and accessing information, including observations and their observational metadata. Requirements for discovery metadata are specified in the *Manual on the WMO Information System* (WMO-No. 1060) and are not considered further here.

2.5.1.1 For all WIGOS observations they make available internationally, Members shall record and retain the observational metadata specified as mandatory in the WIGOS Metadata Standard defined in Appendix 2.4 to this section.

Note 1: The WIGOS Metadata Standard defines a common set of requirements for elements to be provided in observational metadata. It includes a detailed list of mandatory, conditional and optional metadata.

Note 2: A record of “not available”, "unknown" or "not applicable" are valid values for many elements of the WIGOS Metadata Standard. This assists Members to achieve compliance with the standard, particularly in a transitional step towards capability to report actual values.

2.5.1.2 For all WIGOS observations they make available internationally, Members shall record and retain the observational metadata specified as conditional in the WIGOS Metadata Standard in Appendix 2.4 to this section whenever the related condition is met.

2.5.1.3 For all WIGOS observations they make available internationally, Members should record and retain the observational metadata specified as optional in the WIGOS Metadata Standard in Appendix 2.4 to this section.

Note 1: Further requirements for observational metadata beyond the WIGOS Metadata Standard are stated in the following sections of this Manual. In the case of the Global Observing System, as noted in section 7 of this Manual, the *Manual on the GOS* (WMO-No. 544) provides further provisions for GOS metadata.

Note 2: Further guidance on metadata, and on sound metadata practices, is provided in Guides and guidance documentation associated with the individual observing system components.

2.5.2 Exchanging and archiving observational metadata

2.5.2.1 Members shall make available internationally and without restriction, those mandatory observational metadata supporting observations that are made available internationally.

2.5.2.2 Members making observations available internationally shall retain and make available, without restriction, observational metadata for at least as long as they retain the observations described by the observational metadata.

2.5.2.3 Members making available internationally archived observations shall ensure that all WIGOS metadata describing the observations remain available, without restriction, for at least as long as the observations are retained.

2.5.2.4 Members making available internationally archived observations should ensure that any additional observational metadata describing the observations remain available, without restriction, for at least as long as the observations are retained.

2.5.3 Global compilation of observational metadata

2.5.3.1 Members shall make available to WMO for global compilation those components of the WIGOS metadata that are specified as mandatory.

Note: global compilations of WIGOS metadata are held in several databases. The Observing Systems Capabilities Analysis and Review tool (OSCAR) database of the WIGOS Operational Information Resource (WIR) is the key source of information for WIGOS metadata. Other global compilations of specific components of WIGOS metadata include elements of the GAWSIS, the JCOMM Ops database and others.

Appendix 2.4 to this section specifies which components of the WIGOS Metadata Standard are to be made available in OSCAR. Purposes and management of WIGOS Operational Information Resource (WIR) and OSCAR are described in Attachment 2.2 to this section.

2.5.3.2 For all WIGOS component observing systems they operate, Members shall keep the relevant WMO observational metadata databases updated with the required WIGOS metadata.

Note: The mechanisms for making metadata available for global compilation are managed by the WMO Secretariat.

2.5.3.3 Members shall routinely monitor the content of WIGOS metadata databases, and provide feedback to WMO on identified discrepancies, possible errors, and required changes with respect to the WIGOS component observing systems they operate.

2.5.3.4 Members shall designate their national focal points responsible for making available metadata and monitoring content of WMO observational metadata databases, and inform the Secretariat accordingly.

2.5.3.5 Members delegating the responsibility of the national focal point for all or part of the observing networks they operate to a global or regional entity shall inform the Secretariat accordingly.

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APPENDIX 2.4

The WIGOS Metadata Standard

General

This Appendix refers to the "*WIGOS Metadata Standard*",[2] which consists of the set of observational metadata elements to be made available internationally. They are required for the effective interpretation of observations from all WIGOS component observing systems by all observational data users, allowing them to access important information about why, where, and how an observation was made, along with how the raw data has been processed and the quality of the data. Note that WIGOS metadata which is required from specific components or sub-systems is detailed in the sections 3–8 of this Manual.

The table below presents categories (or groups) of metadata, each containing one or more elements. Each element is classified (using the same terminology as is used by ISO) as either mandatory (M), conditional (C), or optional (O).

The definition of each metadata element, together with notes and examples, as well as the explanation of the condition to apply to the conditional elements, can be found in the latest version of the WIGOS Metadata Standard document (0.1.03).

Members' obligations

Mandatory metadata elements shall always be made available. The content of the corresponding fields shall never be empty, either the metadata "value" or the reason for no-value, shall be made available.

Conditional metadata elements shall be made available when the specified condition or conditions are met, in which case the content of the corresponding fields shall never be empty, either the metadata "value" or the reason for no-value, shall be made available.

Optional metadata elements should be made available, as they provide useful information that can help to better understand an observation. Very few elements are considered optional. These elements are likely to be important for a particular community, but less so for others.

Adoption through a Phased Approach

Making available WIGOS metadata will generate substantial benefits for Members, but developing the capacity to make available these metadata also requires a substantial effort on the part of (meta)data providers. To help Members comply with reporting obligations, guidance material will be developed and provided.

Moreover, reporting obligations will be enforced in phases, in order to allow Members sufficient time to develop the capacity to comply. Balancing the effort required to generate and make available individual elements, and the need to have this information to make adequate use of observations, implementation will proceed through three phases as shown in the table below. Importantly, elements required by the end of **Phase I** are either the mandatory elements in WMO Publication No. 9, Vol. A or are of critical importance for the Observing Systems Capability Analysis and Review (OSCAR) tool of the WIR, and are considered of benefit for all WMO Application Areas. **Phase II** adds elements recognized to be more challenging for Members, but the knowledge of which is still of rather immediate need for the adequate use of observations, in particular for assessing quality of observations. **Phase III** adds the remaining elements specified in this version of the standard.

Elements emerging as being important for specific application areas or observing programmes will be added to the standard as it evolves.

[2] Currently available at: http://cbs-ext2014.wmo.int/documents-english

List of elements specified in the WIGOS metadata standard and the phases for Members implementation

Category	Phase I	Phase II	Phase III
	2016	**2017–2018**	**2019–2020**
1. Observed Quantity	**1-01 Name of observed quantity – measurand (M)**	1-05 Representativeness of observation (O)	
	1-02 Measurement unit (M)		
	1-03 Temporal extent of observed quantity (M)		
	1-04 Spatial extent of observed quantity (M)		
	1-06 Observed medium (M)		
2. Purpose of Observation	2-01 Application area(s) (O)		
	2-02 Network affiliation (M)		
3. Data Quality		**3-01 Uncertainty of measurement (M)**	
		3-02 Procedure used to estimate uncertainty (M)	
		3-03 Quality flag (M)	
		3-04 Quality flagging system (M)	
		3-05 Traceability flag (M)	
		3-06 Traceability chain (C)	
4. Environment		*4-04 Exposure of instrument (C)*	*4-01 Surface cover (C)*
		4-05 Intervention at Station/platform (O)	*4-02 Surface Cover classification scheme (C)*
		4-06 Site information (O)	*4-03 Topography or Bathymetry (C)*
5. Data Processing and Reporting	**5-03 Reporting interval (time) (M)**	5-02 Processing/analysis centre (O)	5-01 Data processing methods and algorithms (O)
	5-04 Reporting interval (space) (C)	5-06 Level of data (O)	5-05 Software/processor and version (O)
	5-12 Reference datum (C)	**5-09 Aggregation interval (M)**	**5-07 Data format (M)**
		5-10 Meaning of time stamp (M)	**5-08 Version of data format (M)**
		5-11 Reference time (M)	5-13 Numerical resolution (O)
			5-14 Latency (of reporting) (M)
6. Sampling and Analysis	6-03 Sampling strategy (O)	**6-06 Spatial sampling resolution (M)**	6-01 Sampling procedures (O)
			6-02 Sample treatment (O)
			6-04 Sampling time period (M)
			6-05 Meaning of the time stamp (M)
			6-07 Analytical procedures (O)
			6-08 Temporal sampling interval (M)
7. Station/ Platform	*7-01 Region of origin of data (C)*	**7-04 Station/platform type (M)**	**7-05 Station/platform model (M)**
	7-02 Territory of origin of data (C)	7-08 Data communication method (O)	
	7-03 Station/platform name (M)		
	7-06 Station/platform unique identifier (M)		
	7-07 Geospatial location (M)		
8. Method of Observation	**8-01 Source of observation (M)**	*8-12 Geospatial location (C)*	*8-06 Configuration of instrumentation (C)*
	8-02 Measurement principle (M)		*8-07 Lab calibration interval (C)*
	8-03 Observable range (M)		*8-08 Instrument lab calibration date and time (C)*
	8-04 Instrument stability (C)		*8-09 Instrument model and serial number (C)*
	8-05 Vertical distance (C)		*8-10 Instrument field maintenance (C)*
			8-11 Instrument field verification (C)
9. Ownership and Data Policy	**9-02 Data policy/use constraints (M)**	**9-01 Supervising organization (M)**	
10. Contact			**10-01 Contact (Nominated Focal Point) (M)**

ATTACHMENT 2.2

The WIGOS Information Resource (WIR)

Purpose of the WIR

The WMO Integrated Global Observing System (WIGOS) Information Resource (WIR) is a tool designed to provide WIGOS stakeholders (observing network decision makers, managers, supervisors, implementation coordination groups, observational data users) with all relevant information on the operational status and evolution of WIGOS and its observing components, the operational requirements of WIGOS, including standard and recommended practices and procedures, best practices and procedures used in the WIGOS framework, and their capabilities to meet observational user requirements of the WMO Application Areas. The WIR serves a number of purposes, and brings the following benefits to WMO Members:

(i) To provide general information on WIGOS, its benefits to Members, and the impacts on Members of addressing WIGOS requirements;

(ii) To provide an overall description of the WIGOS component observing systems that are currently in place (list of observing networks, stations, their characteristics (metadata) including information on observational products they deliver);

(iii) To monitor the evolution of the observing systems and compare this with the plans, to ascertain progress;

(iv) To outline existing national and regional plans for evolution of WIGOS component observing systems;

(v) To assist Members and those in charge of observing network design and implementation to understand the requirements for the relevant observing systems, including standard and recommended practices and procedures, and observational user requirements, in order for them to make appropriate decisions;

(vi) To assist Members to identify observational gaps through critical review and to conduct network design studies, in order for them to address those gaps;

(vii) To assist Members to understand the full potential of the current observing systems with regard to the WMO Application Areas, including those systems operated by partner organizations, to enhance: (a) the scope and availability of observations made by specific observing stations; (b) collaborations; (c) data sharing; and (d) data exchange;

(viii) To provide data users with immediate access to the list of WIGOS component observing systems, with a basic set of observational metadata for each (specified by WMO Technical Regulations), and with links to the appropriate national databases where more detailed information is available in those cases where such databases exist;

(ix) To provide developing countries with guidance on observing network implementation, and tools they can readily use to document their own observing systems (e.g. by using the OSCAR tool of the WIR, they could avoid the need to develop a database nationally); and

(x) To provide a mechanism for matching specific needs (capacity building, gaps, etc.) with resources (via knowledge sharing, donor contributions etc.).

Note 1: Observing stations refer to all types of observing sites, stations and platforms relevant to WIGOS, whether they are surface-based, or space-based, on land, at sea, lake, river, or in the air, fixed, or mobile (incl. in the air), and making in-situ or remote observations.

Note 2: Gaps are expressed in terms of required space, and time resolution, observing cycle, timeliness, and uncertainty for the WMO Application Areas.

The Observing Systems Capabilities Analysis and Review tool (OSCAR)

The Observing Systems Capabilities Analysis and Review tool (OSCAR) of the WIR is a key source of information for WIGOS metadata. The surface- and space-based capabilities components of the OSCAR is intended to record observing platform metadata according to the

WIGOS metadata standard described in the *Manual on WIGOS* (WMO-No. XXXX), and to retain a record of the current and historical WIGOS metadata.

Management of OSCAR

The management of OSCAR (i.e. functional specifications and their evolution, and information content management) and its components is overseen by the WMO Secretariat in liaison with relevant expert groups and bodies, and in accordance with the WIGOS agreed upon standard and recommended practices and procedures.

OSCAR content management

The OSCAR will be managed to provide the availability needed to address its purpose. WIGOS metadata is maintained under the authority of the Permanent Representatives with WMO.

The operator of OSCAR will collect feedback from Members on noted discrepancies, possible errors, and required changes, so that the OSCAR information content reflects the reality of the surface and space-based capabilities of the observing platforms they operate, including instrument, and platform metadata.

The WMO Secretariat is responsible to coordinate management of the information content of OSCAR, with assistance from designated experts and focal points.

Current information can be seen at: www.wmo.int/oscar.

2.6. Quality Management

Note 1: The *Technical Regulations* (WMO-No. 49), Volume IV – Quality Management, 2011 edition, provides provisions relating to the WMO Quality Management Framework, WMO QMF.

Note 2: Detailed guidance on how to develop and implement a quality management system (QMS) to ensure and enhance the quality of NMHS products and services is provided in the *Guide to the Implementation of a Quality Management System for National Meteorological and Hydrological Services* (WMO-No. 1100), 2013 edition).

Note 3: Definitions, terminology, vocabulary and abbreviations used in relation to quality management are those of the ISO 9000 family of standards for quality management systems, in particular within ISO 9000:2005, Quality Management Systems – Fundamentals and vocabulary.

Note 4: A QMS can only be implemented by the body which has the resources and the mandate to manage the observing system. While for consistency with the WMO QMF, it is Members who are urged to follow the standard and recommended practices and procedures associated with implementation of a QMS, in practice it is one or more organizations within the Member's country that own and operate observing systems and provide observations and observational metadata, most notably the NMHSs. In practice, then, implementation of the WMO QMF relies on the Member making arrangements for such organizations to implement a QMS.

Note 5: The term "observations" include also "observational metadata" everywhere in the section 2.6 of this Manual.

2.6.1 Scope and Purpose of WIGOS Quality Management

Note: WIGOS practices and procedures enable Members to comply with the WMO QMF in relation to the quality of observations.

2.6.2 WIGOS Component of the WMO Quality Management Framework

2.6.2.1 Quality Policy

2.6.2.1.1 In the establishment and maintenance of WIGOS observing systems, Members should ensure optimum affordable quality for all observations.

2.6.2.1.2 Members should, through a process of continual improvement, pursue effective and efficient management and governance of observing systems.

2.6.2.2 Application of the eight Principles of Quality Management

2.6.2.2.1 Members should apply the eight Principles of Quality Management to the implementation of WIGOS as specified in Appendix 2.5 to this section.

Note: The eight principles of QM are specified in Volume IV of WMO the *Technical Regulations* (WMO-No. 49).

2.6.3 WIGOS Quality Management Processes

Note: The processes and roles of various entities are described in Attachment 1 to this section.

2.6.3.1 Determination and Maintenance of User Requirements

Note: The WMO RRR process for compiling observation user requirements is described in sections 2.1, 2.2.4 and Appendix 2.3 to this Manual.

2.6.3.2 Development and Documentation of Observing Systems Standards and Recommendations

2.6.3.2.1 Through involvement in the work of technical commissions, Members should participate in the development of observing system standard and recommended practices and procedures.

2.6.3.3 Training of Personnel and Capacity Development

2.6.3.3.1 Members should ensure appropriate planning and implementation of training and capacity development activities.

2.6.3.4 Performance Monitoring

2.6.3.4.1 Members should use and respond to the results, advice and reports of designated monitoring centres and any subsequent advice of expert groups.

2.6.3.5 Feedback, Change Management and Improvement

2.6.3.5.1 Members should ensure that inconsistencies (problems) identified by WIGOS Lead and Monitoring Centers are rectified in a timely manner and that a process for their documentation and rectification is implemented and maintained.

2.6.3.5.2 Members should, upon identification or notification of observation quality related inconsistencies, and problems analyze the detected problem and implement necessary improvements to operational practices and procedures so as to minimize their negative impacts and prevent their future reoccurrence.

2.6.3.5.3 Members should ensure that changes to operational practices and procedures are accordingly documented.

2.6.4 WIGOS aspects of the Development and Implementation of the QMS of Members

Note: This section specifies requirements for the integration of WIGOS practices and procedures into the QMS of Members. The requirements are based on the eight clauses of the ISO 9001 standard. The *Guide to the Implementation of a Quality Management System for National Meteorological and Hydrological Services* (WMO-No. 1100) 2013 edition provides extensive explanatory notes about the eight clauses. The five subsections which follow correspond to the last five of the clauses, providing further details about the elements required in a QMS.

2.6.4.1 General requirements for the content of a QMS

2.6.4.1.1 Members should identify their high level processes and their interactions that lead to the provision of observations.

Note: In addition to WIGOS specific provisions, there are many other general requirements for the content of a QMS which are not unique to WIGOS observations hence are not repeated here.

2.6.4.2 Requirements related to management and planning

2.6.4.2.1 Members should clearly demonstrate and document their management commitment to the integration of WIGOS quality management practices within their QMS.

2.6.4.2.2 Members should carefully identify and routinely review user requirements for observations prior to attempting to meet user needs.

2.6.4.2.3 Members should ensure that their published quality policy is consistent with the WIGOS quality policy.

2.6.4.2.4 Members should establish and make known objectives for their future provision of observations so as to provide guidance to stakeholders, users and clients on the expected evolution of and changes to the observing systems that they operate as a contribution to WIGOS.

Note: The objectives referred to in this provision constitute the WIGOS quality objectives.

2.6.4.2.5 Members should appoint a quality manager.

2.6.4.3 Requirements related to resource management

2.6.4.3.1 Members should determine and provide the resources needed to maintain and continuously improve the effectiveness and efficiency of their processes and procedures.

2.6.4.3.2 Members should define the competencies required for staff involved in the provision of observations.

2.6.4.3.3 Members should take steps to rectify any competency shortcomings identified for new or existing employees.

2.6.4.3.4 Members should implement policies and procedures to maintain the infrastructure required for the provision of observations.

2.6.4.4 Requirements related to the provision of observations

2.6.4.4.1 Members should undertake sound planning for the provision of observations.

Note: Such planning includes the following activities and processes:

- Determination and continuous review of user and client requirements;
- The translation of user and client requirements into objectives and targets for observations and observing system design;
- Initial and ongoing allocation of adequate resources for all aspects of the design, implementation and maintenance processes of observing systems;
- Implementation of design processes and activities, including communication strategies and risk management, that will ensure and confirm the development and implementation of observing systems that meet objectives and user and client requirements; and,
- Appropriate and ongoing documentation of planning processes and their results.

2.6.4.4.2 Members should identify their users and establish and document their users' requirements for observations.

Note: The means for doing this include:

i. The WMO Rolling Review of Requirements (RRR) process, described in sections 2.1, 2.2.4 and Appendix 2.3 of this Manual;
ii. Other processes to establish user requirements within WMO Programmes through the activities of WMO technical commissions;
iii. Regional processes through the activities of WMO regional associations and other multi-lateral groupings of Members: and,
iv. National processes.

2.6.4.4.3 Members should have a clear description of the requirements that are agreed upon.

Note: It is important to note the difference between aspirational requirements and agreed requirements. Once requirements are established, this will provide essential information for the monitoring and measurement of conformance.

2.6.4.4.4 Members should identify and adhere to any statutory or regulatory requirements in relation to the provision of observations.

2.6.4.4.5 Members should design and develop, or otherwise implement, observing systems to satisfy the agreed user requirements.

2.6.4.4.6 Members should use a formal change management process to ensure that all changes are assessed, approved, implemented and reviewed in a controlled manner.

2.6.4.4.7 Members should conduct purchasing in a controlled manner.

Note: Observing systems often require large expenditure and are highly specialized, and therefore clear and concise specifications are needed. Staff responsible for purchasing orders or for providing information to suppliers must ensure that the information and specifications provided are clear, unambiguous and based on meeting the design objectives and system requirements to enable the supply of the appropriate and correct products and services. The undertaking of purchasing in a controlled manner entails application of the following activities and processes:

i. Undertaking written specification of all performance requirements for equipment and/or services;
ii. Ensuring that purchasing is subject to a competitive process of more than one candidate for supply of equipment or services;

iii. Assessment of candidates for supply of equipment or services based on merit and suitability for purpose, which can be discerned from:
   a. Written tendering or quotation of candidates;
   b. Experience or reliable anecdotal evidence of past performance: and,
   c. Recommendation of Member or recognized organizations and agencies; and,
iv. Documentation of the purchasing process and outcomes.

2.6.4.4.8 Members should include in their QMS the WIGOS provisions covering methods of observation, calibration and traceability, operational practices, maintenance, and observational metadata.2.6.4.4.9 Members should implement practices and procedures which ensure that observations remain accurate.

Note: Observations need to be checked as they are produced to ensure they meet the agreed requirements. The means to do this include automated algorithms and manual inspection and oversight.

2.6.4.5 Requirements for monitoring, performance measurement, analysis and improvement

2.6.4.5.1 Members should use the agreed user requirements for observations (see 2.6.4.4) as a basis for defining and implementing appropriate measures of performance and success.

Note: It is important to gain a clear understanding of how satisfied users are with observations. It requires the monitoring of information relating to users' perception and whether their expectations have been met. Surveys are commonly used for this purpose.

2.6.4.5.2 Members should implement activities to gain information on the satisfaction of users of observations.

2.6.4.5.3 Members should ensure that staff are made aware of the methods that have been employed for determining user perceptions and expectations and that they are applied consistently.

2.6.4.5.4 Members should regularly conduct and analyse the results of internal audits of WIGOS processes and procedures as part of the management processes of the observing system.

Note: A detailed explanation on the requirements of the internal audit process is provided in the *Guide to the Implementation of a Quality Management System for National Meteorological and Hydrological Services* (WMO-No. 1100) 2013 edition, section "8.2.2 Internal audit".

2.6.4.5.5 Members should monitor the degree of adherence to the defined processes and requirements for producing observations.

Note: Ideally performance monitoring will be conducted against specific Key Performance Indicators and target levels of performance.

2.6.4.5.6 Members should monitor and measure the fitness for purpose and the quality of their observations as they are produced in order to compare their characteristics with the agreed requirements.

Note: The means to do this include:

i. The devising, implementation and routine analysis of manually or automatically generated Key Performance Indicators and their associated targets; and,
ii. Manual inspection and oversight of observational data produced.

2.6.4.5.7 Members should record instances of non-conformity with requirements, and endeavour to rectify problems in a timely manner.

2.6.4.5.8 Members should maintain a documented corrective action procedure relevant to observations.

2.6.4.5.9 Members should specify and implement procedure(s) that describe(s) how non-conforming observations or observational metadata are identified, how they are dealt with, who is responsible for deciding what to do, what action should be taken and what records are to be kept.

Note: A detailed explanation on the requirements of the corrective action process is provided in the *Guide to the Implementation of a Quality Management System for National Meteorological and Hydrological*

Services (WMO-No. 1100) 2013 edition, section "8.2.3 and 8.2.4 Monitoring and measurement of processes and products".

2.6.4.5.10 Members should analyse monitoring results to detect any performance related changes, trends and deficiencies and use the results and analyses as input to activities aimed at continual improvement.

Note: Analysing trends and taking action prior to the occurrence of a case of non-conformity helps to prevent problems.

2.6.4.5.11 Members should maintain documented preventive action procedures relevant to observing systems and ensure that staff are aware of and, if necessary, trained in their routine application.

Note: Due consideration might be given to combining the preventive and the corrective action procedures for efficiency and to simplify the process.

2.6.5 Compliance, Certification and Accreditation

Note: While WMO encourages the certification of Member quality management systems by recognized accreditation agencies, unless otherwise specified as a requirement of a particular WIGOS Component System or subsystem, there is no general regulated requirement for certification of QMS for WIGOS observing systems.

2.6.6 Documentation

2.6.6.1 Members should include the WIGOS quality policy (2.6.2.1) and objectives (2.6.4.2) in their QMS Quality Manual.

2.6.6.2 Members should include in their QMS documentation those documents that describe the procedures related to WIGOS, including in particular those relating to control of non-conforming observations, corrective actions and preventive actions.

2.6.6.3 Members should include in their QMS documentation those documents that describe the procedures required to ensure the effective planning, operation and control of its WIGOS processes.

2.6.6.4 Members should include in their QMS documentation those records required by the ISO 9001 standard.

Note: More detailed information on Documentation requirements is provided in the *Guide to the implementation of a Quality Management System for National Meteorological and Hydrological Servic*es (WMO-No. 1100) 2013 edition, section "4.2 Documentation requirements".

APPENDIX 2.5

Eight Principles of Quality Management of the WMO Quality Management Framework applied to WIGOS

1. User and client focus

Members should identify, document and understand the current and future needs of their users and clients for meteorological, climatological, hydrological, marine and related environmental observations.

Note: The means to achieve this includes participation in and the application of the WMO Rolling Review of Requirements (RRR) process (see section 2.2.4 and Appendix 2.3 of this Manual).

2. Leadership

Members should clearly define the goals and directions of their observing systems and create an environment in which staff are encouraged to work in that direction.

Note: The relevant WMO technical commissions provide technical guidance and leadership for the implementation of WIGOS. They provide information on WIGOS goals and directions, and stimulate the active involvement of technical experts from Member countries.

3. Involvement of people

Experts from Member countries should be fully involved in the implementation of regulations pertaining to WIGOS quality management.

4. Process approach

Members should adopt a process-based approach to management of observing systems.

5. System approach to management

Members should identify, understand and manage WIGOS observing systems as sets of processes that may be operational, scientific or administrative, with the overall objective of producing the required observations outputs.

6. Continual improvement

Members should ensure that continual improvement is an integral and permanent component of WIGOS observing systems and is implemented through a range of processes and activities that include: active participation in the WMO RRR; auditing of observing systems and sites; data quality monitoring and evaluation, and ensuring routine consultation with, and review of feedback from, WIGOS users and Application Areas, primarily through the WMO Rolling Review of Requirements.

Note: The resulting outcome is the improvement of either the quality of observations or the efficiency of observing systems.

7. Factual approach to decision-making

Members should ensure that decisions, requirements and regulations associated with the design, development, implementation, operation, maintenance and evolution of WIGOS observing systems are based on scientifically, factually and analytically derived information.

Note: The above mentioned information is available to Members through tools such as the WMO RRR, the WIGOS Information Resource (WIR), the Observing Systems Capability Analysis and Review (OSCAR) tool, and through WMO endorsed planning documents such as the "*Implementation Plan for Evolution of Global Observing Systems*" (WIGOS Technical Report No. 2013-4) and others. For further information see section 2.2.4, Appendix 2.3 and Attachment 2.2.

8. Mutually beneficial supplier relationships

Members should participate in, and share with each other and with suppliers, information and results of, tests, trials and intercomparisons of instruments and systems, for the mutual benefit of both WIGOS and suppliers.

Note: Suppliers of instruments, systems and related products should be evaluated and selected on the basis of their ability to meet requirements and on the past performance of their products and services.

2.7 CAPACITY DEVELOPMENT

2.7.1 General

2.7.1.1 Members should identify their needs for capacity development in all activity areas of WIGOS.

2.7.1.2 Members should develop plans to meet their capacity development needs.

Note: In addition to national resources allocated to National Meteorological and Hydrological Services, other support may be available to Members such as: other domestic agencies, their WMO regional association, other Members through bilateral or multilateral arrangements, and WMO Programmes (including appropriate technical commissions).

2.7.1.3 Members should establish bilateral and multi-lateral collaborations (within and beyond their Region) where necessary to address significant capacity development needs.

2.7.1.4 When planning capacity development activities, Members should take a holistic approach considering institutional, infrastructural, procedural, and human resources requirements to support both the current and continuing resource requirements for installation, operation, maintenance, inspection, and training. For this purpose, Members should prepare specific capacity development plans with measurable objectives to enable effective implementation, monitoring, and assessment.

Note: Funds to meet these requirements should be sought for a minimum of ten years to assure sustainable networks.

2.7.2 Training

2.7.2.1 Members shall provide adequate training for their staff, or take other appropriate actions to ensure that all staff are suitably qualified and competent for the work assigned to them.

Note: This requirement is applied both to initial recruitment or introductory training and to continuing professional development.

2.7.2.2 Each Member should ensure that the qualifications, competencies, skills (and thus training) and numbers of their personnel or other contractors are well matched to the range of tasks to be performed.

2.7.2.3 Each Member should communicate to the staff their role and how they contribute to the achievement of the quality objectives.

2.7.3 Infrastructural Capacity Development

2.7.3.1 Members should regularly review their infrastructure for collecting and making available observations and observational metadata and, as necessary, develop prioritized plans and priorities for capacity development.

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3. COMMON ATTRIBUTES SPECIFIC TO THE SURFACE-BASED SUB-SYSTEM OF WIGOS

3.1. Requirements

Note: The observational user requirements of WMO Application Areas are expressed in a technology free manner. Hence they apply to all of WIGOS in common, not to any specific sub-system. The provisions of section 2.1 of this Manual apply across all WIGOS sub-systems.

3.2. Design, planning and evolution

3.2.1 Composition of the surface-based sub-system of WIGOS

3.2.1.1 The WIGOS surface-based sub-system shall be composed of surface stations within the component networks (i.e. GOS, GAW, WHOS, GCW).

3.2.1.2 Members should implement elements of the WIGOS surface-based sub-system under the coordination of regional associations when appropriate.

Note: Information regarding the current capabilities of the surface-based subsystem is to be available through the Observing Systems Capability Analysis and Review Tool (OSCAR) at: www.wmo.int/oscar.

3.3. Instrumentation and Methods of Observation

3.3.1 General Requirements

3.3.1.1 Members shall classify their surface meteorological and climatological observing stations on land.

Note 1: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, (1.1.2), Annex 1.B provides guidelines on the classification of surface observing sites on land to indicate their representativeness for the measurement of different variables.

Note 2: The content of Annex 1.B will be included as an Appendix to this section in a future edition.

3.3.1.2 Members should locate each observing station at a site that permits correct exposure of the instruments and enables satisfactory non-instrumental observations.

Note: Requirements for GAW stations are formulated in section 5 of this Manual.

3.3.1.3 Members shall accurately know and refer the position of a station to the World Geodetic System 1984 (WGS-84) and its Earth Geodetic Model 1996 (EGM96).

Note 1: Guidelines are provided in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1 (1.3.3.2).

Note 2: This geodetic system is currently not in general use in hydrology.

Note 3: Its description will be included as an Appendix to this section in a future edition.

3.3.1.4 Members shall define the elevation of the station.

Note 1: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, (1.3.3.2(c)) provides guidelines on defining the elevation of a station.

Note 2: This material will be included as an Appendix to this section in a future edition.

3.3.1.5 If a station is located at an aerodrome, Members shall specify the official elevation of the aerodrome in accordance with the WMO *Technical Regulation* (WMO-No. 49), Volume II, [C.3.1.], Appendix 3, 4.7.2).

3.3.1.6 Members operating Regional Instrument Centres should follow the guidelines concerning capabilities and corresponding functions.

Note 1: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Annex 1.A provides guidelines concerning capabilities and corresponding functions.

Note 2: This material will be included as an Appendix to this section in a future edition.

3.3.1.7 Members operating Regional Marine Instrument Centres should follow the guidelines concerning capabilities and corresponding functions.

Note 1: The Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8), Part II, Chapter 4, Annex 4.A provides guidelines concerning capabilities and corresponding functions for operating Regional Marine Instrument Centres.

Note 2: The content of Annex 4.A will be included as an Appendix to this section in a future edition.

3.3.2 Requirements on Sensors

3.3.2.1 Members shall avoid the use of mercury in their observing systems. Where mercury is still in use, Members shall obey the safety precautions provided.

Note 1: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 3 (3.2.7) provides safety precautions

Note 2: The content of Annex 4.A will be included as an Appendix to this section in a future edition.

3.3.2.2 For inflation of meteorological balloons, Members should prefer helium over hydrogen. If hydrogen is used, however, Members shall obey to the safety precautions provided.

Note 1: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part II, Chapter 10 (10.6.1) provides safety precautions.

Note 2: This material will be included as an Appendix to this section in a future edition.

3.3.2.3 Members shall calibrate all pyrheliometers, other than absolute pyrheliometers, by comparison using the sun as the source with a pyrheliometer that has traceability to the World Standard Group and a likely uncertainty of calibration equal to or better than the pyrheliometer being calibrated.

Note: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 7 (7.2.1.4) provides the detailed guidelines.

3.3.2.4 Members shall compare, calibrate and maintain barometers according to the guidelines.

Note 1: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 3 (3.10), provides guidelines on the comparison, calibration and maintenance of barometers.

Note 2: This material will be included as an Appendix to this section in a future edition.

3.4. Operations

3.4.1 General Requirements

3.4.1.1 Members operating surface-based observing systems shall follow the provisions of the section 2.4.1.

3.4.2 Observing Practices

3.4.2.1 Members shall ensure that the exposure, when applicable, of instruments for the same type of observation at different stations be similar in order that observations may be compatible.

3.4.2.2 Members shall determine a reference height for at each surface observing station or system.

Note: A reference height is defined as follows:

1. Elevation of the station. It is the datum level to which barometric pressure reports at the station refer; such current barometric values being termed "station pressure" and understood to refer to the given level for the purpose of maintaining continuity in the pressure records; or
2. For stations not located on aerodromes: elevation of the ground (height above mean sea level of the ground on which the raingauge stands or, if there is no raingauge, the ground beneath the thermometer screen. If there is neither raingauge nor screen, it is the average level of terrain in immediate vicinity of station) in metres rounded up to two decimals; or
3. For stations located on aerodromes it is an official altitude of the aerodrome.

3.4.3 Quality Control

3.4.3.1 Members operating surface-based observing systems shall follow the provisions of the section 2.4.3.

3.4.4 Data and Metadata Reporting

3.4.4.1 Members operating surface-based observing systems shall follow the provisions of the section 2.4.4.

3.4.5 Incident Management

3.4.5.1 Members operating surface-based observing systems shall follow the provisions of the section 2.4.5.

3.4.6 Change Management

3.4.6.1 Members should compare observations from new instruments over an extended interval before the old measurement system is taken out of service or when there has been a change of site. Where this procedure is impractical at all sites, Members should carry out comparisons at selected representative sites.

Note 1: This does not apply to all types of stations and among the exceptions are hydrological stations.

Note 2: Further details can be found in the *Guide to Climatological Practices* (WMO-No. 100), including the required minimum intervals for such comparison.

3.4.7 Maintenance

3.4.7.1 Observing sites and instruments should be maintained regularly so that the quality of observations does not deteriorate significantly between station inspections.

Note: Detailed guidance on maintenance of observing sites, observing systems and instruments is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), the *Guide to Hydrological Practices* (WMO-No. 168, 2008) and the *Manual on Stream Gauging* (WMO-No. 1044, 2010).

3.4.8 Inspection and Supervision

3.4.8.1 Members shall arrange for its surface observing site, station, system to be inspected at sufficiently frequent intervals to ensure that a high standard of observations is maintained; instruments and all their indicators are functioning correctly; and the exposure, when applicable, of the instruments has not changed significantly.

Note 1: Reference is made to the sections 5–8 of this Manual for the frequency intervals specified for the different types of WIGOS surface observing stations.

Note 2: Detailed guidance on the inspection including the frequency is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part III, Chapter 1.

Note 3: Reference is made to the *Technical Regulations* (WMO-No. 49), Volume II for provisions on the inspection of aeronautical meteorological stations including its frequency.

3.4.8.2 Members shall ensure that inspection is performed by qualified and adequately trained staff.

3.4.8.3 When performing inspection, Members should ensure that:

(a) The siting, selection and installation, as well as exposure when applicable, of instruments are known, recorded and acceptable;

(b) Instruments have approved characteristics, are in good order and regularly verified against relevant standards;

(c) There is uniformity in the methods of observation and in the procedure for reduction of observations.

Note: Detailed guidance on inspection and supervision of observing systems and sites is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) including all of the GAW measurement guides as referenced in Chapter 16 of the Guide, the *Guide to Hydrological Practices* (WMO-No. 168) and the *Manual on Stream Gauging* (WMO-No. 1044).

3.4.9 Calibration Procedures

Note: Provisions of 2.4.9 apply.

3.4.9.1 Members operating surface-based observing systems shall follow the provisions of the section 2.4.9.

3.5 Observational Metadata

Note: Detailed guidance regarding the establishment, maintenance and update of metadata records is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, 1.3.4 and Part III, Chapter 1, 1.9; *Guide to Climatological Practices* (WMO-No. 100), Chapter 3, 3.3.4; *Guide to the Global Observing System* (WMO-No. 488), Appendix III.3, and the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, Chapter 10.

3.5.1 Members operating surface-based observing systems shall follow the provisions of the section 2.5.

Note: Further provisions specific to the WIGOS component observing system appear in sections 5, 6, 7 and 8 of this Manual.

3.6. Quality Management

3.6.1 Members operating surface-based observing systems shall follow the provisions of the section 2.6.

Note: Further provisions specific to the WIGOS space-based sub-system appear in section 4 of this Manual; specific to the WIGOS component observing system appear in sections 5, 6, 7 and 8 of this Manual.

3.7. Capacity Development

3.7.1 Members operating surface-based observing systems shall follow the provisions of the section 2.7.

Note: Further provisions specific to the WIGOS space-based sub-system appear in section 4 of this Manual; specific to the WIGOS component observing system appear in sections 5, 6, 7 and 8 of this Manual.

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4. COMMON ATTRIBUTES SPECIFIC TO THE SPACE-BASED SUB-SYSTEM OF WIGOS

4.1. Requirements

4.1.1 General

4.1.1.1 Members shall strive to develop, implement and operate a space-based environmental observing system in support of WMO Programmes as described in Attachment 4.1 to this section.

Note: The space-based sub-system of WIGOS is established through dedicated satellites, remotely observing the characteristics of the atmosphere, the earth and the oceans.

4.1.2 Observed Variables

4.1.2.1 This sub-system shall provide quantitative data enabling, independently or in conjunction with surface-based observations, the determination of variables including but not limited to:

(a) Three-dimension fields of atmospheric temperature and humidity;

(b) Temperature of sea and land surfaces;

(c) Wind fields (including ocean surface winds);

(d) Cloud properties (amount, type, top height, top temperature, and water content);

(e) Radiation balance;

(f) Precipitation (liquid and frozen);

(g) Lightning;

(h) Ozone concentration (total column and vertical profile);

(i) Greenhouse gas concentration;

(j) Aerosol concentration and properties;

(k) Volcanic ash cloud occurrence and concentration;

(l) Vegetation type and status and soil moisture;

(m) Flood and forest fire occurrence;

(n) Snow and ice properties;

(o) Ocean colour;

(p) Wave height, direction and spectra;

(q) Sea level and surface currents;

(r) Sea ice properties;

(s) Solar activity;

(t) Space environment (electric and magnetic field, energetic particle flux, electron density).

Note: Information regarding the current capabilities of the space-based subsystem is available through the Observing Systems Capability Analysis and Review Tool (OSCAR) at: www.wmo.int/oscar.

4.1.3 Observing performance requirements

4.1.3.1 Satellite operators providing observational data to WIGOS shall strive to meet, to the extent possible, the uncertainty, timeliness, temporal and spatial resolution, and coverage requirements of WIGOS as defined in the WIGOS Information Resource (WIR), based on the Rolling Requirements Review process described in section 2 of this Manual.

Note 1: The term “satellite operators” is used in the *Manual on WIGOS* (WMO-No. XXXX) to refer to “Members or coordinated group of Members operating environmental satellites”.

Note 2: A coordinated group of Members operating environmental satellites is a group of Members acting jointly to operate one or more satellites through an international space agency such as the European Space Agency or EUMETSAT

Note: These requirements are recorded and maintained in the requirements database: http://www.wmo.int/oscar.

4.1.4 Global planning

4.1.4.1 Satellite operators shall cooperate to ensure that a constellation of satellite systems is planned and implemented to guarantee the continuous provision of space-based observations in support of WMO Programmes.

Note: Collaboration is pursued within the Coordination Group for Meteorological Satellites, which includes all Members operating space-based observation systems in support of WMO Programmes.

4.1.5 Continuity

4.1.5.1 Satellite operators working together under the auspices of the Coordination Group for Meteorological Satellites or otherwise, should ensure the continuity of operation, and of the data dissemination and distribution services of the operational satellites within the sub-system through appropriate contingency arrangements and re-launch plans.

4.1.6 Overlap

4.1.6.1 Satellite operators should ensure an adequate period of overlap of new and old satellite systems in order to determine inter-satellite instrumental biases and maintain the homogeneity and consistency of time series observations, unless reliable transfer standards are available.

4.1.7 Interoperability

4.1.7.1 Satellite operators shall achieve the greatest possible interoperability of their different systems.

4.1.7.2 Satellite operators shall make available sufficient technical details about the instruments, data processing, transmissions, and the dissemination schedules for Members to fully exploit the data.

4.2. Design, planning and evolution

Note: The space-based sub-system is composed of:

a. An Earth observation space segment;

b. An associated ground segment for data reception, processing, dissemination, and stewardship;

c. A user segment.

4.2.1 Space segment architecture

Note: The overall architecture of the space segment is described in Attachment 4.1 to this section.

It is defined and evolves in consultation with the Coordination Group for Meteorological Satellites.

It includes:

- A constellation of geostationary satellites;
- A core constellation of sun-synchronous satellites distributed over three separated orbital planes;
- Other operational satellites operated on either sun-synchronous orbits or other appropriate Low-Earth orbits;
- Research and Development satellites on appropriate orbits.

4.2.2 Space programme life cycles

4.2.2.1 Satellite operators shall consider a trade-off between the need for a long series to pay-off the development cost and the user learning curve, on one hand, and the need to develop a new generation in order to benefit from state-of-the-art technology, on the other hand.

Note 1: The development of an operational satellite programme is conducted in several phases including: user requirements definition, feasibility assessment at system level, preliminary design, detailed design, development and testing of the subsystems, integration of all subsystems, system testing, launch campaign, and on-orbit commissioning. The overall duration of these development phases is typically of the order of 10 to 15 years.

Note 2: The exploitation phase for an operational programme including a series of recurring satellites is typically of the order of 15 years.

4.3. Instruments and Methods of Observation

Note 1: Space-based observation relies on a wide range of sensor types, e.g. active or passive, operating in various spectral ranges, with various scanning or pointing modes. Information on the principles of Earth Observation from space, the different types of space-based instruments and the derivation of geophysical variables from space-based measurements can be found in the *Guide to Instruments and Methods of Observation*, (WMO-No. 8), Part III.

Note 2: Detailed characteristics of current and planned systems of environmental satellites are available in the satellite module of the Observing System Capabilities Analysis and Review tool (OSCAR), which is available on line (http://www.wmo.int/oscar/space). It also contains an indication of the main instruments that are relevant for each specific variable observable from space, with their potential performance for the respective variables.

4.3.1 Calibration and Traceability

4.3.1.1 Satellite operators shall perform a detailed instrument characterization before launch.

Note: Members must strive to follow the pre-launch instrument characterization guidelines recommended by the Global Space-based Inter-calibration System.

4.3.1.2 After launch, satellite operators shall calibrate all instruments on a routine basis against reference instruments or calibration targets.

Note 1: Advantage should be taken of satellite collocation to perform on-orbit instrument intercomparison and calibration.

Note 2: Calibration must be done in accordance with established and documented methodologies by the Global Space-based Inter-calibration System and the CEOS Working Group on Calibration and Validation.

4.3.1.3 Satellite operators shall ensure traceability to International Standards (SI) according to international approved standards.

Note: The Implementation Plan for the Global Climate Observing System (WMO/TD-No. 1253) calls for sustained measurement of key variables from space traceable to reference standards, and recommends implementing and evaluating a satellite climate calibration mission.

4.3.1.4 To ensure traceability to International Standards (SI), satellite operators shall define a range of ground-based reference targets for calibration purposes.

4.4. Space Segment Implementation

4.4.1 Operational satellites on Geostationary Earth Orbit

4.4.1.1 Satellite operators should implement an operational constellation of satellites in geostationary orbit as described in Attachment 4.1 to this section.

4.4.1.2 Satellite operators shall ensure that the constellation of satellites in geostationary orbit provides full disc imagery at least every 15 minutes, throughout a field of view between 60° S and 60° N.

Note: This implies the availability of at least six operational geostationary satellites if located at evenly distributed longitudes, with in-orbit redundancy.

4.4.1.3 Satellite operators should implement rapid-scan capabilities where feasible.

4.4.1.4 For the imagery mission in geostationary orbit, satellite operators should ensure an availability rate of rectified and calibrated data of at least 99 percent as a target.

4.4.1.5 To meet the essential requirement for continuity of data delivery, satellite operators, shall strive to implement contingency plans, involving the use of in-orbit stand-by flight models and rapid call-up of replacement systems and launches.

4.4.2 Core operational constellation on sun-synchronous Low Earth Orbits

4.4.2.1 Operators of LEO satellites should implement a core operational constellation of satellites in three regularly distributed sun-synchronous orbits as described in Attachment 4.1 to this section.

4.4.2.2 Operators of the core constellation of environmental LEO satellites on three sun-synchronous orbital planes in early morning, mid-morning and afternoon orbit, shall strive to ensure a high level of robustness allowing the delivery of imagery and sounding data from at least three polar orbiting planes, on not less than 99 percent of occasions.

Note: This implies provisions for a ground segment, instrument and satellite redundancy, and rapid call-up of replacement launches or on orbit spares.

4.4.3 Other capabilities on sun-synchronous Low Earth Orbits

4.4.3.1 Operators of environmental LEO satellites should implement capabilities in appropriate orbits as described in Attachment 4.1 to the section.

4.4.4 Research and Development satellites

4.4.4.1 Operators of Research and Development satellites shall consider providing the following observing capabilities:

(a) Advanced observation of the parameters necessary to understand and model the water cycle, the carbon cycle, the energy budget and the chemical processes of the atmosphere;

(b) Pathfinders for future operational missions.

Note: For WMO, the main benefits of Research and Development satellite missions are:

- Support of scientific investigations of atmospheric, oceanic, and other environment related processes,
- Testing or demonstration of new or improved sensors and satellite systems in preparation for new generations of operational capabilities to meet WMO observational requirements.

4.4.4.2 Members shall strive to optimize the usefulness of observations from Research and Development satellites for operational applications. In particular, operators of Research and Development satellites shall make provisions, where possible, to enable near real-time data availability to promote the early use of new types of observations for operational applications.

Note 1: Although neither long-term continuity of service nor a reliable replacement policy are assured, research and development satellites provide, in many cases, observations of great value for operational use.

Note 2: Although they are not operational systems, Research and Development satellites have proven to support operational meteorology, oceanography, hydrology and climatology substantially.

4.5 Ground Segment Implementation

4.5.1 General

4.5.1.1 Satellite operators shall make observational data available to Members over the WMO Information System (WIS) in accordance with the provisions in the *Manual on the WMO Information System* (WMO-No. 1060). Satellite operators shall inform Members of the means of

obtaining these data through catalogue entries and shall provide sufficient metadata to enable meaningful use of the data.

4.5.1.2 Satellite operators shall implement facilities for the reception of remote-sensing data (and Data Collection System data when relevant) from operational satellites, and for the processing of quality-controlled environmental observation information, with a view of further near real-time distribution.

4.5.1.3 Satellite operators shall strive to ensure that data from polar-orbiting satellites are acquired on a global basis, without temporal gaps or blind orbits, and that data latency meets WMO timeliness requirements.

4.5.2 Data dissemination

4.5.2.1 Satellite operators shall ensure near real-time data dissemination of the appropriate data sets, per the requirement of Members, either via an appropriately designed ground segment, by direct broadcast, or by re-broadcast via telecommunication satellites.

4.5.2.2 In particular, operators of operational sun-synchronous satellites providing the core meteorological imagery and sounding mission should ensure inclusion of Direct Broadcast capability as follows:

(a) Direct broadcast frequencies, modulations, and formats should allow a particular user to acquire data from either satellite by a single antenna and signal processing hardware. To the extent possible, the frequency bands allocated to Meteorological Satellites should be used;

(b) Direct broadcast shall be provided through a high data rate stream, such as the High Resolution Picture Transmission (HRPT) or its subsequent evolution, to provide meteorological centres with all the data required for numerical weather prediction (NWP), Nowcasting, and other real-time applications;

(c) If possible, a low data rate stream should also be provided, such as the Low Rate Picture Transmission (LRPT), to convey an essential volume of data to users with lower connectivity or low-cost receiving stations.

4.5.2.3 Satellite operators shall consider implementing re-broadcast via telecommunication satellites to complement and supplement direct broadcast services, to facilitate access to integrated data streams including data from different satellites, to non-satellite data and to geophysical data products.

4.5.3 Data Stewardship

4.5.3.1 Satellite operators shall provide full descriptions of all processing steps taken in the generation of satellite data products, including algorithms, characteristics, and outcomes of validation activities.

4.5.3.2 Satellite operators shall preserve long-term raw data records and ancillary data required for their calibration, reprocessing as appropriate, with the necessary traceability information to achieve consistent Fundamental Climate Data Records.

4.5.3.3 Satellite operators shall maintain Level 1B satellite data archives including all relevant metadata pertaining to the location, orbit parameters and calibration procedures used.

4.5.3.4 Members shall ensure that their archiving system is capable of providing on-line access to the archive catalogue with a browsing facility, provides adequate description of data formats, and will allow users to download data.

4.5.4 Data collection systems

4.5.4.1 Satellite operators with a capability to receive data and/or products from Data Collection Platforms (DCP) shall maintain technical and operational coordination under the auspices of CGMS in order to ensure compatibility.

4.5.4.2 Satellite operators shall maintain a number of “international” DCP channels identically on all geostationary satellites to support the operation of mobile platforms moving across all individual geostationary footprints.

4.5.4.3 Satellite operators shall publish details of the technical characteristics and operational procedures of their data-collection missions, including the admission and certification procedures.

4.5.5 User Segment

4.5.5.1 Operators of research and development satellites shall implement capabilities enabling Members to access the data in one of the following ways: via downloading data from server(s), via receiving data from a re-broadcasting service, or via receiving from a direct broadcast capability.

4.5.5.2 Members shall endeavour to install and maintain in their territory at least one system enabling access to digital data from both LEO and geostationary operational satellite constellations, either a receiver of re-broadcast service providing the required information in an integrated way, or a combination of dedicated direct readout stations.

4.5.5.3 Where appropriate, Members should strive to utilize fixed or moving DCP systems (for example to cover data-sparse areas) to take advantage of the data-collection and relay capability of the environmental observation satellites.

4.6. Observational Metadata

4.6.1 For each space-based system they operate, satellite operators shall record, retain and make available observational metadata in accordance with the provisions of section 2.5 of this Manual.

4.7. Quality Management

4.7.1 Quality Indicators

4.7.1.1 Satellite operators shall include appropriate quality indicators in the metadata for each datasets, in accordance with the provisions of section 2.5 of this Manual.

4.8. Capacity Development

4.8.1 Centres of Excellence

4.8.1.1 Satellite operators, and other Members having the capability to do so, shall provide support to education and training of instructors in the use of satellite data and capabilities e.g. at specialized Regional Meteorological Training Centres or other training institutes designated as Centres of Excellence in satellite meteorology, in order to build up expertise and facilities at a number of regional growth points.

4.8.2 Training strategy

4.8.2.1 Satellite operators should focus their assistance, to the extent possible, on one or more of these Centres of Excellence within their service areas and contribute to the Virtual Laboratory for Training and Education in Satellite Meteorology.

Note: The aim of the Education and Training strategy implemented through the Virtual Laboratory is to systematically improve the use of satellite data for meteorology, operational hydrology, and climate applications, with a focus on meeting the needs of developing countries.

4.8.3 User preparation for new systems

4.8.3.1 In order to facilitate a smooth transition to new satellite capabilities, satellite operators should make provisions for appropriate preparation of the users through training, guidance to necessary upgrades of receiving equipment and processing software, and information and tools to facilitate the development and testing of user applications.

4.8.3.2 In addition to working through the Virtual Laboratory, Members should, as appropriate, exploit partnerships with organizations providing education and training in environmental satellite applications, depending on their specific needs.

4.8.4 Engagement between Users and Data Providers

4.8.4.1 In order to achieve the most effective utilization of satellite data, Members should pursue the close engagement between users and data providers at a regional level.

4.8.4.2 Working with their regional association, Members should follow systematic steps to document the regional requirements for satellite data access and exchange.

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ATTACHMENT 4.1

CGMS BASELINE FOR THE OPERATIONAL CONTRIBUTION TO THE GOS

(adopted by CGMS-39 on 6 October 2011)

FUTURE SATELLITE MISSIONS TO BE PERFORMED ON OPERATIONAL/SUSTAINED BASIS

INTRODUCTION

In support of the programmes coordinated or co-sponsored by WMO for weather and climate, CGMS Members plan to maintain the operational capabilities and services described below, that constitute the "CGMS baseline for the operational contribution to the GOS".

While this particular document focuses on missions that are decided and managed in an operational or sustained framework, with a perspective of long-term follow-on, this in no way precludes the importance of other missions undertaken e.g. on a research or demonstration basis. First of all, because today's research and development are the foundation of tomorrow's operational missions. Furthermore, because many missions initiated in an R&D framework for a limited duration are eventually extended well beyond their design life time and provide longstanding support to both scientific and operational activities.

This baseline defines a constellation of geostationary satellites, a core meteorological mission on three sun-synchronous orbits, other missions in sun-synchronous orbits, missions in other Low Earth Orbits, and contains cross-cutting considerations on contingency planning, inter-calibration, data availability and dissemination.

I. Constellation in geostationary orbit

At least six geostationary satellites shall be operated at evenly distributed locations with in orbit redundancy, and perform the following missions:

(a) Advanced visible and infrared imagery (at least 16 spectral channels, 2km resolution) over the full disc at least every 15 minutes

(b) Infrared sounding (hyperspectral on some positions)

(c) Lightning detection

(d) Data collection

(e) Space environment monitoring

On selected positions, the following missions shall be performed:

(f) Earth Radiation Budget monitoring

(g) High spectral resolution UV sounding

(h) Solar activity monitoring

II. LEO sun-synchronous missions

Operational sun-synchronous satellites shall be operated around three orbital planes in mid-morning ("am", nominally 09:30 descending, 21:30 ascending ECT), afternoon ("pm", nominally 13:30 ascending ECT) and early morning (nominally 05:30 descending, 17:30 ascending ECT) and, as a constellation, shall perform the following missions:

1) Core meteorological mission nominally on 3 orbital planes

(a) Multispectral visible and infrared imagery

(b) Infrared hyperspectral sounding (at least am and pm)

(c) Microwave sounding

(d) Microwave imagery

2) Other missions on sun-synchronous orbits

(e) Wind scatterometry over sea surfaces (at least two orbital planes)

(f) Ocean surface topography by radar altimetry (at least on am and pm orbits, supplemented by a reference mission on a high-precision, inclined orbit)

(g) Radio-occultation sounding (at least am and pm, supplemented by a constellation in specific orbits)

(h) Broadband VIS/IR radiometer for Earth Radiation balance (at least am and pm)

(i) Total Solar Irradiance (at least one)

(j) Contribution to atmospheric composition observations (at least am and pm)

(k) Narrow-band Vis/NIR imagers (at least one sun-synchronous, am spacecraft) for ocean colour, vegetation and aerosol monitoring

(l) High-resolution multi-spectral Vis/IR imagers (constellation of sun-synchronous satellites, preferably in am)

(m) IR dual-angle view imagery for high-accuracy SST (at least one am spacecraft)

(n) Particle detection and/or electron density (at least am and pm)

(o) Magnetic field (at least am and pm)

(p) Solar activity (at least two)

(q) Data collection

III. Other LEO missions

The following missions shall be performed on an operational basis by Low Earth Orbit satellites on appropriate orbits:

(a) Ocean surface topography by radar altimetry (A reference mission on high-precision, inclined orbit, complementing two instruments on sun-synchronous am and pm orbit)

(b) Radio-Occultation sounding (dedicated constellation of sensors on appropriate orbits)

IV. Contingency Planning

The CGMS baseline is associated with contingency plans for geostationary and polar-orbiting satellite systems, which are detailed in the CGMS Global Contingency Plan[3].

V. Inter-calibration

Instruments should be inter-calibrated on a routine basis against reference instruments or calibration sites. The routine and operational intercalibration and corrections shall be performed in accordance with standards as agreed by the Global Space-based Inter-calibration System (GSICS).

3 The Global Contingency Plan (http://www.wmo.int/pages/prog/sat/documents/CGMS_Global-Contingency-Plan_version2_070507.pdf) should be updated accordingly. It should indicate that in case of potential gaps on core sun-synchronous missions, absolute priority should be given to observation from mid-morning and early afternoon orbits, in order to maintain the continuity of these datasets.

VI. Data availability and dissemination

VI.1. Data open availability with suitable timeliness

All operational environmental observation satellite systems should be designed to ensure the provision of data with suitable timeliness, as appropriate for their intended applications. Data should be preserved for the long term and documented with metadata allowing their interpretation and utilization. The satellite operators should establish dissemination contents and schedules that take into account the data requirements of users. Re-broadcast via telecommunication satellites should complement and supplement direct broadcast services, which allows cost-efficient access to integrated data streams including data from different satellites, non-satellite data and geophysical products. The dissemination systems should utilize all-weather resilient telecommunication means.

VI.2. Direct broadcast for core meteorological missions in LEO

The core meteorological satellite systems in LEO orbits, and other operational observation satellite systems when relevant, should ensure near real-time data dissemination of imagery, sounding, and other real-time data of interest to Members by direct broadcast. Direct broadcast frequencies, modulations, and formats for polar-orbiting satellites should allow a particular user to acquire data from either satellite by a single antenna and signal processing hardware. Direct Broadcast should use allocations in all-weather resilient frequency bands.

VII. Note

The present update of the CGMS baseline is adopted in the light of satellite mission plans as they are known in October 2011.

5. OBSERVING COMPONENT OF THE GLOBAL ATMOSPHERE WATCH

Note: The provisions of sections 1, 2, 3 and 4 of this Manual are common to all WIGOS component observing systems, including the GAW. The further provisions of section 5 of this Manual are specific to GAW.

General

5.1 The observing component of the GAW Programme shall be a coordinated system of networks of observing stations, facilities, expert teams and related procedures devoted to the observation of the changing chemical composition and related physical characteristics of the atmosphere.

Note: The GAW Programme has six focal areas: ozone, greenhouse gases, reactive gases, aerosols, UV radiation and precipitation chemistry. GAW stations in addition to measuring one or more of the parameters related to these foci may also measure ancillary variables, like radiation, radio nuclides, and persistent organic pollutants.

5.1. Requirements

5.1.1 Members should perform the observations of atmospheric composition and related physical parameters using a combination of surface-based stations and platforms (fixed stations, mobile platforms and remote sensing) and space-based platforms.

5.1.2 Members should use the requirements from the RRR process, particularly in the atmospheric chemistry application area in developing their GAW stations.

Note 1: The user requirements are reviewed on a regular basis through the RRR process by the Scientific Advisory Groups for each variable, in consultation with the user community and input from Members. The RRR process is described in sections 2.1, 2.2.4 and Appendix 2.3.

Note 2: Scientific Advisory Groups exist for the six GAW focal areas and their terms of reference are defined by the Commission for Atmospheric Sciences.

5.1.3 Members should follow the Data Quality Objectives specified by the GAW Programme for the individual variables observed.

5.1.4 Members should establish and operate their GAW stations such that they satisfy the station requirements specified in Attachment 5.1 to this section.

5.1.5 Members operating GAW stations shall undertake long-term and uninterrupted operation with stability and continuity of data collection that is adequate for purpose outlined in 5.2.1.

5.2. Design, planning and evolution

5.2.1 Members should design, plan and further evolve their GAW observing network and stations to address the user requirements and, in particular those that concern key environmental issues and application areas, including but not limited to the following areas:

- Stratospheric ozone depletion and the increase of ultraviolet (UV) radiation.
- Changes in the weather and climate related to human influence on atmospheric composition, particularly, related to the changes in greenhouse gases, ozone and reactive gases, and aerosols.
- Risk assessment of air pollution on human health and agriculture and issues involving long-range transport of air pollution and its deposition.

5.2.2 Members should contribute observations through operating or supporting suitable platforms at GAW stations and/or through contributing networks.

5.2.3 When doing so, Members shall register their contribution in the GAW station information system (GAWSIS), and submit their observations to the relevant GAW Data Centre.

5.2.4 Members operating a contributing network shall provide a description of the network and register the stations in GAWSIS and provide corresponding metadata.

5.2.5 Members should ensure that the frequency and spacing of the various observations is suited to the temporal and spatial requirements of the specific issues addressed in section 5.2.1.

5.3. Instrumentation and Methods of Observation

5.3.1 General requirements of Instruments

5.3.1.1 Members should use recommended types of instruments or methods of observation for variables observed at their stations, and follow further guidance available.

Note 1: Guidance is provided in the Standard Operating Procedures (SOPs) and Measurement Guidelines (MG).

Note 2: Instruments suitable for use at GAW sites are defined by the Scientific Advisory Groups for each parameter, in terms of stability, precision and accuracy.

Note 3: SOP describe the standard approach to operate this kind of instrument.

Note 4: MG describe the standard approach for this kind of measurement regardless of the instrument.

5.3.2 Calibration and Traceability

5.3.2.1 Members shall perform calibrations and maintain traceability to the GAW primary standards, where available.

Note 1: GAW primary standard is a single network standard, assigned by WMO. In the case of contributing networks the network observations are traceable to the network standard, which in turn is traceable to GAW primary standard.

Note 2: Details on calibrations are specified by the Standard Operating Procedures and Measurement Guidelines.

5.3.2.2 Members should utilize GAW central facilities to sustain the global compatibility of observations.

Note: GAW central facilities include: Central Calibration Laboratories, World Calibration Centres, Regional Calibration Centres, Quality Assurance/Scientific Activities Centres.

5.4. Operations

5.4.1 Observing system implementation monitoring

5.4.1.1 Members shall monitor the operation of GAW stations for which they are responsible and ensure that they follow the relevant procedures for quality assurance and data submission. Members shall seek assistance from Central Facilities, Scientific Advisory Groups and Expert Teams if operational problems cannot be solved locally.

Note: The procedures to be used in monitoring the operation of GAW are determined within the Commission for Atmospheric Sciences (CAS) in consultation with the participating Members.

5.4.1.2 Members should systematically monitor compliance with GAW regulations, in collaboration with relevant constituent bodies and the Secretariat, in order to identify critical cases of non-compliance (deficiencies) and undertake measures for their timely resolution.

5.4.2 Quality Assurance

5.4.2.1 Members should follow specified quality assurance practices and procedures.

Note: Details are given in the GAW Standard Operational Procedures and Measurement Guidelines, and further documents provided by the Scientific Advisory Groups and Central Facilities.

5.4.2.2 Members shall maintain detailed metadata records in accordance with procedures and practices specified in this Manual.

5.4.2.3 Members should participate in independent evaluation of quality of observations, including intercomparisons and system audits, as appropriate to the observed variables.

5.4.2.4 Members shall permit World Data Centres to perform independent evaluation of the data quality of their observations.

5.4.3 Data and Metadata representation and format

5.4.3.1 Members shall submit their observational data and associated metadata to the relevant GAW World Data Centres for the variables observed at the station within agreed time limits.

5.4.3.2 Members shall use the formats specified by the relevant World Data Centre when submitting their observational data and metadata.

5.5. Observational Metadata

Note: The general provisions on observation metadata are specified in section 2.5.

5.5.1.1 Members shall provide metadata associated with instrumentation, site or platform, calibration history as requested by the World Data Centre for each parameter, and by GAWSIS.

5.5.1.2 Members shall provide such additional metadata as required by GAWSIS and any World Data Centre to which they contribute that are necessary to understand their observations.

5.6. Quality Management

Note: The general regulations on Quality management are specified in section 2.6.

5.7. Capacity Development

Note: General provisions for capacity development are provided in sections 2.7, 3.7 and 4.7 of this Manual.

5.7.1 Members not capable of implementing required standards should establish agreements with appropriate Central Facilities or establish partnership with more experienced stations in the form of stations twinning.

Note: In some regions of the world, and for some GAW variables, where there is a clear lack of capacity, Members may be requested to help support a station, or existing stations may be approached to become a part of GAW. Such requests and invitations come after approval by the appropriate SAGs.

5.7.2 Members should use the GAW Training and Education Centre (GAWTEC) programme, as available for capacity building and staff training in measurement of the specific GAW variables.

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ATTACHMENT 5.1

General requirements for GAW stations

Essential characteristics of GAW Regional Stations:

1. The station location is chosen such that, for the variables measured, it is regionally representative and is normally free of the influence of significant local pollution sources.

2. There are adequate power, air conditioning, communication and building facilities to sustain long term observations with greater than 90% data capture (i.e. <10% missing data).

3. The technical support provided is trained in the operation of the equipment.

4. There is a commitment by the responsible agency to long-term observations of at least one of the GAW variables in the GAW focal areas (ozone, aerosols, greenhouse gases, reactive gases, UV radiation, and precipitation chemistry).

5. The GAW observations made are of known quality and linked to the GAW Primary Standard.

6. The data and associated metadata are submitted to one of the GAW World Data Centres, typically no later than one year after the observations are made. Changes of metadata including instrumentation, traceability, observation procedures, are reported to the responsible WDC in a timely manner.

7. If required, observations are submitted to a designated data distribution system in near real-time.

8. Standard meteorological in situ observations, necessary for the accurate determination and interpretation of the GAW variables, are recommended to be made with known quality.

9. The station characteristics and observational programme are updated in the GAW Station Information System (GAWSIS) on a regular basis.

10. A station logbook (i.e. record of observations made and activities that may affect observations) is maintained and is used in the data validation process.

Additional Essential characteristics needed for a GAW Global Station:

In addition to the essential characteristics of Regional stations, a GAW Global station should fulfil the following additional requirements, namely:

11. Measure variables in at least three of the six GAW focal areas.

12. Have a strong scientific supporting programme with appropriate data analysis and interpretation within the country and, if possible, the support of more than one agency.

13. Provide a facility at which intensive campaign research can augment the long term routine GAW observations and where testing and development of new GAW methods can be undertaken.

GAW Contributing Networks

GAW contributing networks involve observations from multiple stations. The stations comprising contributing networks should satisfy the criteria of either regional or global stations adjusted by the contributing network regulations (e.g. within the contributing network data submission requirements or standard used can differ from those required for regional and global stations). In the case of standards different from the WMO standards, the network standards must have a confirmed traceability to the WMO standards in the cases where such standards exist. Data submission regulations for the contributing networks must be not worse than the ones required within GAW. A station designation of global or regional, if it already exists for individual stations, always takes precedence. To be used in global assessments data from the contributing stations must be submitted to the GAW World Data Centres.

6. OBSERVING COMPONENT OF THE GLOBAL CRYOSPHERIC WATCH

Note: The provisions of sections 1, 2, 3 and 4 of this Manual are common to all WIGOS component observing systems including the GCW. The further provisions of section 6 of this Manual are specific to the GCW.

6.1 Members should collaborate actively in, and give all possible support to, the development and implementation of the observing component of Global Cryosphere Watch.

Note: GCW implementation encompasses the use of surface- and space-based observations, observing standard and recommended practices and procedures, and best practices for the measurement of essential cryospheric variables, and full assessment of error characteristics of in situ and satellite products. The initial focus of CryoNet, the surface-based standardized core observing network, is to promote the addition of cryospheric observations taken according to GCW standard and recommended practices and procedures, guidelines and best practices, at existing sites rather than creating new sites. The development of GCW includes the development of a CryoNet Guide.

6.2 Members should encourage partnerships between organizations to coordinate observing, capacity building and training activities relevant to cryospheric observations and to assist with the compilation and development of manuals on standard and recommended practices and procedures for cryospheric observation.

6.3 CryoNet shall be structured in three different classes of observational sites: Baseline sites, Reference sites, and Integrated sites with the following requirements:

- ***Baseline*** sites shall make measurements of at least one element of the cryosphere; e.g. snow, permafrost, sea ice, or glaciers. Baseline sites should be targeted toward long-term, continuous measurements.
- ***Reference*** sites shall be the key sites of CryoNet with respect to the assessment of long-term changes of the cryosphere as well as for the validation of satellite data and cryospheric models. The reference site shall provide continuous measurements over a long period. Reference sites should be for operational purposes or may have a research focus.
- The ***Integrated*** sites shall promote, through worldwide scientific collaboration, progress in the scientific understanding of the physical processes that change the cryosphere. These sites shall integrate in situ and space-based observations and create platforms of cryospheric observatories. Monitoring at integrated sites should cover multiple components of the cryosphere with a highly process orientated approach. Integrated sites shall either be a single station or several stations or field sites covering a larger region. In general these sites shall be supported by long-term financial commitments running standard monitoring programs of the cryosphere.

6.4 For inclusion of a GCW surface measurement site or station in CryoNet, Members and partners shall meet defined criteria. The minimum requirements are in Attachment 6.1.

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ATTACHMENT 6.1

The minimum requirements for inclusion of a GCW surface measurement site or station in CryoNet

1. The site location is chosen such that, for the variables measured, it is spatially/temporally representative for measuring one or several components of the cryosphere.

2. User needs have been considered in the observation design process.

3. CryoNet sites have to be active and perform sustained observations according to CryoNet agreed practices.

4. Technical personnel are trained in the operation and maintenance of the equipment.

5. For reference and integrated sites, there is an intent by the responsible agencies to sustain long-term observations of at least one of the CryoNet variables. For baseline sites the responsible agencies intend to support a long-term observing program.

6. The relevant CryoNet observations are of documented quality. The measurements are made and quality controlled according to CryoNet agreed practices.

7. Associated standard meteorological in situ observations, when necessary for the accurate determination and interpretation of the GCW variables, are made with documented quality.

8. A station logbook for observations and activities that may affect observations is maintained and used in the data validation process.

9. The data and metadata including changes in instrumentation, traceability, observation procedures are submitted to a data centre that is interoperable with the GCW portal in a timely manner.

10. The station characteristics and observational programme information are kept up-to-date in the GCW station information database. Station metadata are also provided to the WMO Operational Information Resource (WIR) and maintained regularly.

7. GLOBAL OBSERVING SYSTEM OF THE WORLD WEATHER WATCH

Note 1: The provisions of sections 1, 2, 3 and 4 of this Manual are common to all WIGOS component observing systems including the GOS.

Note 2: Provisions specific to the GOS are currently set out in the *Manual on the Global Observing System* (WMO-No. 544), Volume I).

8. WHO HYDROLOGICAL OBSERVING SYSTEM

Note: The provisions of sections 1, 2, 3 and 4 of this Manual are common to all WIGOS component observing systems, including the WHOS. The further provisions of section 8 of this Manual are specific to the WHOS.

8.1 Requirements

8.1.1 Members shall establish and operate a hydrological observing system according to its national requirements.

8.1.2 Members should also operate their hydrological observing systems to address the requirements of the RRR process, in particular for the hydrology application area.

Note 1: A hydrological observing system includes networks of hydrological observing stations as defined in Technical Regulations Volume III – Hydrology, Chapter D.1.1 which should make observations of elements as described in Chapter D.1.2 Hydrological Observations.

Note 2: Chapter D.1.4 Hydrological Data Transmission states "Transmission facilities should be organized for the international exchange of hydrological data, forecast and warnings on the basis of bilateral or multilateral agreement." Further provisions for data transmission and international exchange through the WMO Information System (WIS) are given in the *Technical Regulations*, Volume I, Part II and the *Manual on WMO Information System* (WMO-No. 1060) and the *Manual on Global Telecommunication System* (WMO-No. 386), Volume I.

8.1.3 Members shall provide on a free and unrestricted basis those hydrological data and products which are necessary for the provision of services in support of the protection of life and property and for the well-being of all peoples.

8.1.4 Members should also provide additional hydrological data and products where available, which are required by WMO Programmes and its Members as specified in 8.1.2.

8.1.5 At a global level, the WMO Hydrological Observing System (WHOS) shall allow access to sources of hydrological observations in near-real time from Members around the world.

Note: Currently, many Members are making such observations publically available on the Internet.

8.1.6 Members should provide these sources of observations to the WHOS.

Note: Hydrological observations available through WHOS will initially comprise stage (water level) and discharge. This will likely expand over time to include other elements as identified in the Rolling Review of Requirements process at the national, regional and global levels.

8.2 Design, planning and evolution

Note: Design, planning and evolution is common to all WIGOS component observing systems.

8.2.1 Members should design and plan their observing network considering the review of the current and planned WMO Hydrological Observing System capabilities, undertaken as outlined in the Rolling Review of Requirements (RRR) as described in section 2.2.4 of this Manual.

8.3 Instrumentation and Methods of Observation

8.3.1 General Requirements of Instruments

8.3.1.1 Members should equip their stations with properly calibrated instruments and should arrange for these stations to follow adequate observational and measuring techniques to ensure that the measurements and observations of the various hydrological elements are accurate enough to address the needs of hydrology and other applications areas.

Note: Technical Regulations Volume III provides that Members should use instruments for measurement of stage (water level) in conformance with the specifications of its Annex II — Water level measuring devices.

8.3.1.2 Members should ensure that the uncertainty in the observation of the stage (water level) of rivers, estuaries, lakes, and reservoirs not exceed:

(a) In general, 10 mm at the 95 per cent confidence level;

(b) Under difficult conditions, 20 mm at the 95 per cent confidence level.

Note: Stage (Water level) observations are used primarily as an index for computing streamflow discharge when a unique relation exists between stage (water level) and discharge.

8.3.2 Stage and discharge observations from hydrometric stations

Note: Technical Regulations, Volume III provides that Members should establish and operate hydrometric stations for measuring stage (water level), velocity and discharge in conformance with the specifications of its Annex VI — Establishment and operation of a hydrometric station.

8.3.2.1 Members should ensure that the number of discharge measurements at a stream gauging station are adequate to define the rating curve for the station at all times.

Note 1: Technical Regulations, Volume III provides that Members should use the methods for determining the stage-discharge relation (rating curve) of a station as specified in its Annex VII — Determination of the stage-discharge relation.

Note 2: Technical Regulations, Volume III provides that Members should, when undertaking moving-boat discharge measurements, ensure that equipment and operational procedures are as specified in its Annex XII — Discharge measurements by the moving-boat method.

8.3.2.2 Members should measure river discharges to an accuracy commensurate with flow and local conditions. Percentage uncertainty of the discharge measurement should not exceed:

(a) In general, 5 per cent at the 95 per cent confidence level;

(b) Under difficult conditions, 10 per cent at the 95 per cent confidence level.

Note 1: Technical Regulations, Volume III provides that Members should evaluate the uncertainty in discharge measurements in conformance with the specifications in its Annex VIII — Estimation of uncertainty of discharge measurements.

Note 2: Discharge measurements are taken to establish and verify the stability of a rating curve. Stage (water level) observations are converted to estimates of discharge using the rating curve on an on-going basis.

8.3.3 Calibration Procedures

Note 1: Technical Regulations, Volume III provides that Members should adhere to the specifications of facilities, equipment and procedure for the calibration of current meters as specified in its Annex I — Calibration of current meters in straight open tanks.

Note 2: Technical Regulations, Volume III provides that Members should ensure that operational requirements, construction, calibration and maintenance of rotating element current meters are as specified in its Annex IV — Rotating element type current meters.

8.3.3.1 Members should recalibrate acoustic velocity meters on a routine basis to ensure stability of the calibration, using measurement standards traceable to international or national standards. Where no such standards exist, Members should record the basis used for calibration or verification.

Note: Additional information pertaining to the calibration of instruments can be found in the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, and the *Manual on Stream Gauging* (WMO-No. 1044).

8.4 Operations

8.4.1 Observing Practices

8.4.1.1 Members should collect and preserve their hydrological records.

8.4.1.2 Members should make the necessary arrangements to facilitate the retrieval and analysis of their hydrological observations by automatic data-processing equipment.

8.4.1.3 Where automatic registration is not available, Members should ensure the observations of elements for hydrological purposes are made at regular intervals appropriate for the elements and their intended purposes.

8.4.1.4 Members should maintain in their archives an up-to-date inventory of their hydrological observations.

8.4.1.5 Members should generally ensure uniformity in time of observations within a catchment area.

8.4.1.6 Members should select the time units used in processing hydrological data for international exchange from the following:

(a) The Gregorian calendar year;

(b) The months of this calendar;

(c) The mean solar day, from midnight to midnight, according to the zonal time, when the data permit;

(d) Other periods by mutual agreement in the case of international drainage basins or in the case of drainage basins in the same type of region.

8.4.1.7 For hydrometric stations where data are internationally exchanged, Members should process the following characteristics for each year:

(a) Maximum instantaneous and minimum daily mean values of stages (water levels) and discharge;

(b) Mean daily stages (water levels) and/or mean daily discharges.

8.4.1.8 For rivers under flood conditions or where there are variable controls, Members should make special measurements at intervals frequent enough to define the hydrograph.

8.4.1.9 When sudden and dangerous increases in river levels occur, Members should make and report observations as soon as possible without regard to the usual time of observation, to meet the intended operational use.

8.4.1.10 Members should measure and store stage (water level) observations as instantaneous values rather than averaged values.

8.4.2 Quality Control

8.4.2.1 Members should maintain detailed records for each station and for each parameter, containing metadata related to the measurements, maintenance and calibration of equipment.

8.4.2.2 Members should perform periodic audits of their stations and collected data.

8.4.2.3 Members should ensure that recorded hydrological observations are converted to a form suitable for archiving and retrieval.

Note: Observations may be initially recorded using various media from paper to electronic digital form. As computer archiving has become a standard practice by most Members, it is advantageous to convert data to the required format early in the process.

8.4.2.4 Members should ensure their data undergo, at various stages, a range of checks to determine their uncertainty and correctness.

8.4.2.5 With accelerating developments in technology, Members should ensure that data-processing and quality control systems are well-organized and that the relevant staff are trained to understand and use them.

Note: Data are collected and recorded in many ways, ranging from manual reading of simple gauges to a variety of automated data-collection, transmission and filing systems.

8.4.2.6 Members should consider the adoption of a quality management system, as described in section 2.6 of this Manual.

Note: Organizations usually employ an accredited certification agency to provide independent verification.

8.4.2.7 Members should undertake data processing and quality control as described in relevant publications.

Note: Such publications include the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, Chapter 9, the *Manual on Flood Forecasting and Warning* (WMO-No. 1072), Chapter 6 and the *Manual on Stream Gauging* (WMO-No. 1044), Volume II, Chapter 6.

8.4.3 Observations and Observational Metadata Reporting

8.4.3.1 Members should ensure when making available hydrological information for international purposes the use of open text or appropriate code forms as specified on the basis of bilateral or multilateral agreements.

8.4.3.2 Members should ensure that transmission facilities are organized for the international exchange of hydrological observations on the basis of bilateral or multilateral agreement.

8.4.3.3 In order to make data globally available for real-time exchange and for discovery, access and retrieval, Members should report stage and discharge observations in compliance with WMO Information System (WIS) metadata standards.

Note 1: WIS may also be used for access to hydrological observations not required in real time.

Note 2: The regulation governing exchanges in international code forms, are specified in the *Manual on Codes* (WMO-No. 306), Volume I).

Note 3: Coded information exclusively for bilateral or multilateral exchange amongst Members may be in other forms by mutual agreement.

8.4.4 Incident Management

Note: General provisions for Incident Management are provided in section 2.4.5 of this Manual.

8.4.5 Change Management

Note: General provisions for Change Management are provided in section 2.4.6 of this Manual.

8.4.6 Maintenance

8.4.6.1 Members should determine the frequency and timing of visits to recording stations by the length of time that the station can be expected to function without maintenance and the uncertainty requirements of the data.

Note 1: There is a relation between the frequency of the visits and the resultant quality of the data collected. Too long a time between visits may result in frequent recorder malfunction and, thus, in loss of data, while frequent visits are both time consuming and costly.

Note 2: Some data collection devices may suffer a drift in the relationship between the variable that is recorded and that which the recorded value represents. An example of this is a non-stable stage-discharge relationship.

Note 3: Two visits per year are considered an absolute minimum, and preferably more often to avoid the dangers of losing data and/or having data severely affected by problems such as silting, vandalism or seasonal vegetative growth.

8.4.6.2 In such cases, Members should schedule periodical visits to the station to recalibrate the equipment or the measurement equations.

8.4.6.3 Members should periodically inspect stations using trained personnel to ensure the correct functioning of instruments.

8.4.6.4 In addition, Members should ensure a formal written inspection is done routinely, preferably each year, to check overall performance of instruments (and local observer, if applicable).

8.4.6.5 Members, when routinely inspecting sites, should:

(a) Measure gauge datum to check for and record any changes in levels:

(b) Check the stability of the rating curve, review the relationships between the gauges and permanent level reference points to verify that no movement of the gauges has taken place;

(c) Review the gauging frequency achieved and the rating changes identified; and

(d) Undertake a number of maintenance activities as described in section 8.4.6.8 and 8.4.6.9 of this Manual.

Note: It is vital, for the quality of data, that resources for gaugings be allocated and prioritized using rigorous and timely analysis of the probability and frequency of rating changes.

8.4.6.6 Members should ensure maintenance activities are conducted at data-collection sites at intervals sufficient to ensure that the quality of the data being recorded is adequate.

8.4.6.7 Members should ensure such activities are conducted by the observer responsible for the sites, if there is one. Members should ensure such activities are also occasionally performed by an inspector.

8.4.6.8 Members should undertake the following maintenance activities at all collection sites:

(a) Service the instruments;

(b) Replace or upgrade instruments, as required;

(c) Retrieve or record observations;

(d) Perform the recommended checks on retrieved records;

(e) Carry out general checks of all equipment, for example, transmission lines;

(f) Check and maintain the site to the recommended specifications;

(g) Check and maintain access to the station;

(h) Record, in note form, all of the above activities;

(i) Comment on changes in land use or vegetation;

(j) Clear debris and overgrowth from all parts of the installation.

8.4.6.9 Members should undertake the following maintenance activities at discharge collection sites:

(a) Check the bank stability, as necessary;

(b) Check the level and condition of gauge boards, as necessary;

(c) Check and service the flow-measuring devices (cableways, etc.), as necessary;

(d) Check and repair control structures, as necessary;

(e) Regularly survey cross-sections and take photographs of major station changes after events or with vegetation or land-use changes;

(f) Record, in note form, all of the above activities and their results; and

(g) Inspect the area around or upstream of the site, and record any significant land-use or other changes in related hydrological characteristics, such as ice.

Note: Further details are found in the *Manual on Stream Gauging* (WMO-No. 1044).

8.4.6.10 Members should have a well-trained technician or inspector visit stations immediately after every severe flood in order to check the stability of the river section and the gauges. If there is a local observer, Members should train this person to check for these problems and communicate them to the regional or local office.

8.4.6.11 Members should not programme flood gaugings as part of a routine inspection trip because of the unpredictable nature of floods.

8.4.6.12 Members should establish a flood action plan prior to the beginning of the storm or flood season and should specify priority sites and types of data required.

Note: If flood gaugings are required at a site, the preparations ideally would be made during the preceding dry or non-flood season so that all is ready during the annual flood season.

8.4.6.13 Members should consider undertaking the following additional measures if severe flooding is likely:

(a) Upgrade site access (helipad, if necessary);

(b) Equip a temporary campsite with provisions;

(c) Store and check gauging equipment; and

(d) Flood-proof instrumentation such as stage recorders.

8.4.6.14 Following the recession of floodwaters, Members should pay particular attention to ensuring the safety and security of the data-collection site and to restoring normal operation of on-site instrumentation.

Note: In some cases, redesign and reconstruction of the site may be required. Such work would ideally take into account information obtained as a result of the flood.

8.4.7 Calibration procedures

Note: Determination of a rating curve is described in section 8.3.2. Calibration procedures for current meters, is described in section 8.3.3.

8.5 Observational Metadata

Note 1: Provisions for describing observational metadata, for recording and retaining observational metadata, and for exchanging and archiving observational metadata are provided in section 2.5 of this Manual. These apply to all WIGOS component observing systems including the WHOS. Further provisions specific to WHOS are stated here.

Note 2: The contents of observational metadata are detailed in Appendix 2.4 to this Manual including WIGOS metadata and other metadata of specific relevance for WHOS.

Note 3: Within an organization or country, a hydrological information system or a station registration file and a historical operations file (as indicated in the Guide to Hydrological Practices, WMO–No.168) or similar repositories may be used as a convenient means to compile a set of metadata about a hydrological station and its observations.

8.5.1 In addition to the provisions in section 2.5 to this Manual, Members should record, retain and make available the WIGOS observational metadata and also the additional observational metadata specified in the Appendix 2.4 to this Manual.

8.5.2 Members who use their own station identifiers for hydrological stations should maintain the means to match these with the WMO station identifiers, as specified in Appendix 2.4 to this Manual.

8.5.3 Members should collect and record additional detailed observational metadata identifying the purpose of the station in accordance with provisions in section 2.5 to this Manual.

Note: Further details are found in the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, Chapter 10.

8.6 Quality Management

Note 1: Provisions for the implementation of quality management in WIGOS are provided in section 2.6 of this Manual. These apply to all WIGOS component observing systems including the WHOS.

Note 2: The WMO Hydrology and Water Resources Programme has developed material on the implementation of the WMO Quality Management Framework in Hydrology and for adopting this in national operations. Some Members have achieved compliance with the ISO 9001:2008 standard and examples have been documented to assist other Members.

8.7 Capacity Development

Note 1: Provisions for the implementation of capacity development in WIGOS are provided in section 2.7 of this Manual.

Note 2: Whatever the level of technical sophistication of a data-collection authority, the quality of its staff remains its most valuable resource.

8.7.1 Members should undertake careful recruitment, training and management to attain and maintain the appropriate personnel with the most appropriate skill sets.

8.7.2 Members should pursue a carefully structured training programme for all personnel engaged in field and office practices pertaining to data collection because they are in a strong position to influence the quality of the final data.

Note: Formal training ideally will aim at providing both a general course in first principles, plus training modules to teach in-house field and office procedures. All material is to be relevant and current.

8.7.3 Members should provide training classes, follow-up exercises, and on-the-job training to field personnel before they make streamflow and survey measurements using various technologies such as ADCP and mechanical current meters.

8.7.4 Members should provide training classes, follow-up exercises, and on-the-job training on data collection practices and processing of data to increase employee productivity and programme effectiveness.

8.7.5 Members should have appropriate technologies in place, such as hydrological information systems, to allow for streamflow data processing and to allow the effective and efficient delivery of metadata, data and data products to users.

8.7.6 Members should have adequate number of stations to meet priority needs and ensure sufficient resources to maintain and operate sites to attain required accuracies and reliability of data for their intended use.

Recommendation 17 (CBS-Ext.(2014))

ENHANCEMENT AND EXPANSION OF AIRCRAFT-BASED OBSERVATIONS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The operational status of the aircraft meteorological data relay (AMDAR) observing system, as a component of the Global Observing System and the World Weather Watch Programme,

(2) The overall significant and positive impact of the increasing availability of aircraft-based observations on the Global Telecommunication System,

(3) The great potential to address deficiencies in upper-air data coverage over many WMO Regions through further development and expansion of AMDAR and aircraft-based observations,

(4) The justification for the expansion and enhancement of aircraft-based observations based on the relevant global actions within the CBS *Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP)* (Technical Report 2013-4),

Considering:

(1) That the CBS Expert Team on Aircraft-Based Observing Systems has undertaken a study that identifies many airlines that can be targeted by Members for participation in the AMDAR programme to address gaps in upper-air data coverage,

(2) That the Expert Team has consolidated and updated standards and guidance material that can assist Members in the development of new AMDAR programmes,

(3) That efficiencies in use of Member resources and more optimal data coverage can be achieved through regional collaboration on the planning and development of national aircraft-based observations programmes,

Recommends:

(1) That regional associations and Members consider further development of aircraft-based observations, primarily through wider implementation of the AMDAR programme;

(2) That the regional associations and Members collaborate with the Commission to develop, maintain and implement regional plans for the enhancement and expansion of aircraft-based observations and AMDAR, which might be maintained under the respective Regional WMO Integrated Global Observing System Implementation Plans of each regional association;

Requests the Secretary-General to provide support for the coordination of the development and maintenance of these planning and implementation activities through appropriate promotion to Members and at each regional association session.

Recommendation 18 (CBS-Ext.(2014))

SUPPORT OF MEMBERS TO THE IMPLEMENTATION OF THE MARINE METEOROLOGICAL AND OCEANOGRAPHIC OBSERVING SYSTEM IN SUPPORT OF NUMERICAL WEATHER PREDICTION

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Recommendation 6 (CBS-15) – Implementation Plan for the Evolution of Global Observing Systems), and actions G52, G53 and G54 in particular,

(2) Resolution 10 (EC-65) – Report of the fifteenth session of the Commission for Basic Systems relevant to integrated observing systems,

(3) The *Final Report of the Fifth WMO Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction* (WIGOS Technical Report No. 2012-1),

(4) The *Final Report of the Eighth Session of the OPAG on Integrated Observing Systems Implementation/Coordination Team on Integrated Observing Systems (ICT-IOS)* (Geneva, 7–10 April 2014),

(5) The report of the *Ocean Observations Panel for Climate Tropical Pacific Observing System, 2020 Workshop (TPOS 2020), Volume I: Workshop Report and Recommendations* (GCOS Report No. 184) (San Diego, United States of America, 27–30 January 2014),

(6) The *Executive Summary of the Abridged Final Report with Resolutions and Recommendations of the Fourth Session of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology* (WMO-No. 1093),

(7) The Data Buoy Cooperation Panel (DBCP) *Global Data Buoy Observations, A DBCP Implementation Strategy*, Twelfth Edition 2013 (DBCP Technical Document No. 15)

Considering:

(1) The importance of global observing systems to address all the requirements of WMO application areas,

(2) That marine meteorological and oceanographic observations are not only required by climate monitoring and ocean applications, but also by other WMO applications areas such as numerical weather prediction,

Recognizing:

(1) That sea-level pressure cannot be observed adequately from space with the current technology,

(2) That impact studies have shown a high impact on numerical weather prediction on a per observation basis of sea-level pressure from drifters,

(3) That the drifter technology is cost-effective, and that provisional estimates suggest that the impact/cost of drifter data is higher than for all the other observing systems,

(4) That substantial benefits can potentially be gained by National Meteorological and Hydrological Services through a collaboration with oceanographic institutes that deploy standard drifters, and are offering opportunities through the Data Buoy Cooperation Panel for the purchase of barometer upgrades on such drifters,

(5) That the tropical moored buoys also provide valuable surface meteorological and upper ocean observations not only for climate monitoring but also for numerical weather prediction, seasonal to interannual forecasting and tropical cyclone forecasting,

(6) That pending the redesign of the Tropical Pacific Observing System by 2020, there is need to maintain the tropical moored buoy array and assure data availability to an acceptable level,

Noting with concern:

(1) The risks of reduced funding of the barometer drifter array,

(2) The drop in the last two years of the data availability of the tropical moored buoy array due to vandalism on the data buoys, and difficulties to assure maintenance due to the cost of ship time, and piracy,

Recommends:

(1) That Members contribute to the DBCP Implementation Strategy, and commit appropriate resources to the barometer drifter and the tropical moored buoy array;

(2) That National Meteorological and Hydrological Services collaborate with partner organizations and use the opportunity of the DBCP barometer drifter upgrade scheme;

(3) That Members take steps to return the tropical moored buoy array to at least 80 per cent data return as soon as possible, while design and planning work is carried out for the future Tropical Pacific Observing System;

Requests the Secretary-General to bring this recommendation to the attention of Members.

Recommendation 19 (CBS-Ext.(2014))

CRITICAL ROLE OF WMO INFORMATION SYSTEM NETWORKS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 1 (Cg-XVI) – World Weather Watch Programme for 2012–2015,

(2) The *Manual on the WMO Information System* (WMO-No. 1060),

Recognizing:

(1) The increasing requirement for the global exchange of all types of environmental data in addition to the established ongoing exchange of meteorological data and products under the auspices of the World Weather Watch and other WMO Programmes, including the Global Framework for Climate Services,

(2) The basic responsibility of Members and their National Meteorological and Hydrological Services (NMHSs) to provide universal services in support of safety, security and economic benefits for the peoples of their countries,

(3) The dependence of Members and their NMHSs on the stable, cooperative international exchange of meteorological and related data and products for discharging their responsibilities,

(4) The continuing requirement for governments to provide for the meteorological infrastructure of their countries,

(5) The continuing need for, and benefits from, strengthening the capabilities of NMHSs, in particular in developing countries, to improve the provision of services,

(6) The dependence of the research and education communities on access to meteorological and related data and products,

Recommends that the Seventeenth World Meteorological Congress consider the important role of information exchange between National Meteorological and Hydrological Services with an aim to having inter-NMHS information exchange recognized within the United Nations as a critical component of ensuring public and economic safety and well-being.

Recommendation 20 (CBS-Ext.(2014))

UPDATES TO THE *MANUAL ON THE WMO INFORMATION SYSTEM* (WMO-No. 1060)

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 1 (Cg-XVI) – World Weather Watch Programme for 2012–2015,

(2) Resolution 4 (Cg-XVI) – Report of the extraordinary session (2010) of the Commission for Basic Systems relevant to Technical Regulations concerning the Global Telecommunication System, data management and the WMO Information System,

(3) Resolution 51 (Cg-XVI) – Designation of Centres of the WMO Information System,

(4) Resolution 12 (EC-64) – Designation of Centres of the WMO Information System,

(5) Resolution 13 (EC-65) – Amendments to the *Manual on the WMO Information System* (WMO-No. 1060),

(6) The *Manual on the WMO Information System* (WMO-No. 1060),

Noting further:

(1) That WMO Information System (WIS) Implementation Plans are under way in Regions II (Asia), III (South America), V (South-West Pacific) and VI (Europe) and are being developed for Regions I (Africa) and IV (North America, Central America and the Caribbean),

(2) That many candidate WIS centres have now successfully undergone technical assessment,

Considering the recommendations from the Implementation Coordination Team on Information Systems and Services reflecting the experience of making the WMO Information System operational,

Recommends the following modifications to the *Manual on the WMO Information System*, to take effect from 1 July 2015:

(1) To improve the clarity and consistency of the Manual as described in Annex 1 to the present recommendation;

(2) To remove the conditional reference to centres' designations as described in Annex 2, Table 1 to the present recommendation;

(3) To remove the conditional reference to centres' designations and to add designated centres as described in Annex 2, Table 2 to the present recommendation;

(4) To remove centres with conditional designation, other than Global Information System Centre Casablanca, from Appendix B of the Manual, that have not demonstrated their WIS compliance to the Commission;

(5) To amend Parts II and IV of the Manual as indicated in Annex 3 to the present recommendation;

Encourages those centres listed in Annex 2, Table 2 to the present recommendation that have not been endorsed by the Commission to complete the WIS Demonstration Process as soon as possible;

Requests the Secretary-General to make the amendments to the Manual, as given in Annexes 2 and 3 to the present recommendation;

Authorizes the Secretary-General to update the present recommendation to incorporate written notifications from the Commission, regional associations and Global Information System Centres;

Further authorizes the Secretary-General to make any consequent editorial amendments to the Manual.

Annex 1 to Recommendation 20 (CBS-Ext.(2014))

CONSISTENCY AND CLARIFICATION OF THE *MANUAL ON THE WMO INFORMATION SYSTEM* (WMO-NO. 1060)

Changes resulting from changes to WMO Technical Regulations

1. Make the following changes in Part I

1.1.1 In keeping with the Technical Regulations (WMO-No. 49), Volume I, ~~A.3~~Part I, 3.3.2, centres operated by WMO Members …

1.5 Discovery, access and retrieval function

As required per the Technical Regulations (WMO-No. 49), Volume I, ~~A.3~~Part I, 3.3.5, WIS shall be based on catalogues that …

2. Make the following changes in Part II

2.1.2 As required per the Technical Regulations (WMO-No. 49), Volume I, ~~A.3~~Part I, 3.3.3, Congress …

2.4.1 Background

As required per the Technical Regulations (WMO-No. 49), Volume I, ~~A.~~3Part I, 3.3.8, each NC shall use WIS …

3.7.1.1 As required per the Technical Regulations (WMO-No. 49), Volume I, ~~A.~~3Part I, 3.3.8, each NC shall use WIS …

3.7.5.1 As required per the Technical Regulations (WMO-No. 49), Volume I, ~~A.~~3Part I, 3.3.9, each NC shall …

3. Make the following changes in Appendix C, Part 1. WMO Core Metadata Profile Version 1.3 Specification: Conformance Requirements

2.1 Conformance requirements

The WMO Technical Regulations (WMO-No. 49) paragraph ~~A.3.3~~Part I, 3.3.5 states:

~~A.3.3.4 WIS functions and operation shall be based on catalogues that contain metadata describing data and products available across WMO, plus metadata describing dissemination and access options. […]~~

3.3.5 The WMO Information System functions and operation shall be based on catalogues that contain metadata for data and products available across WMO, and metadata describing dissemination and access options. These catalogues shall be maintained by WMO Information System Centres.

4. Make the following changes in Appendix A, Selected WMO documents relevant to WIS

Policy documents

WMO-No. 15 Basic Documents No. 1 ~~(2011 edition)~~

Guides

…

WMO-No. 1061 Guide to the WMO Information System

WMO-No. 1116 Guide on VPN via the Internet between GTS centres

WMO-No. 1115 Guide on IT Security

…

~~Miscellaneous (GTS)~~

~~Guide on VPN via the Internet between GTS centres~~

~~Guide on IT Security~~

5. Make the following changes to clarify meaning and readability

3.5.6.2 See also 4.9, WIS-TechSpec-8 (DAR catalogue search and retrieval) and 4.10, WIS-TechSpec-9 (Consolidated view of distributed DAR metadata (WIS Discovery Metadata) catalogues).

3.6.8.2 See also 4.9, WIS-TechSpec-8 (DAR catalogue search and retrieval) and 4.10, WIS-TechSpec-9 (Consolidated view of distributed DAR metadata (WIS Discovery Metadata) catalogues).

In the list in paragraph 4.1.1, **change** item 9 to:

9. Consolidated view of distributed DAR metadata (WIS Discovery Metadata) catalogues;

4.2.2 Uploading shall use methods prescribed by the receiver, which is typically the host of a WIS DAR metadata (WIS Discovery Metadata) catalogue.

4.2.4 For updating the DAR metadata (WIS Discovery Metadata) catalogue, GISCs should support two kinds of maintenance facilities: a file-upload facility for batch updating (add, replace or delete metadata records treated as separate files) and an online form for changing metadata entries in the DAR metadata (WIS Discovery Metadata) catalogue (add, change or delete elements in a record, as well as whole records).

4.2.5 GISCs shall maintain the updated DAR metadata (WIS Discovery Metadata) catalogue as a searchable resource (see WIS-TechSpec-8).

4.9 WIS-TechSpec-8: Discovery, access and retrieval metadata (WIS Discovery Metadata) catalogue search and retrieval

4.10.2 The exchange of metadata catalogue updates should satisfy the requirement for distributed instances of DAR metadata (WIS Discovery Metadata) not …

6. Make the following Changes to Appendix C to address confusion between Parts I and II of the Manual and Parts 1 and 2 of Appendix C

In Appendix C, change the label for Part 1 to Part C1, and that for Part 2 to Part C2, and modify all cross-references within the Manual accordingly.

7. Make the following change to clarify how information intended for global exchange is identified

Add a note to paragraph 3.5.5.1

Note: The method used in WIS Discovery Metadata records to identify information intended for global exchange is defined in Appendix C, Part C1, requirement 9.1.1.

8. Updates to improve the consistency and clarity of WMO-No. 1061 The Guide to the WMO Information System

1 Make the following change in Part I

1.5.1 As required by Technical Regulations, Vol. I, Part I, ~~3~~3.3.5, and the Manual on WIS, 1.5, WIS is based on metadata catalogues describing data and products available across WMO, …

2 Make the following change in Part II in paragraph 2.2

2.2 Procedures for designating a Global Information System Centre (GISC) are given in the Manual on WIS, 2.2, in keeping with Technical Regulations, Volume I, Part I, ~~3~~3.3.3.

3 Make the following change in Part II in paragraph 2.3

2.3 Procedures for designating a DCPC are given in the Manual on WIS, 2.3, in keeping with Technical Regulations, Volume I, Part I, ~~3~~3.3.4.

Annex 2 to Recommendation 20 (CBS-Ext.(2014))

WMO INFORMATION SYSTEM CENTRES

Table 1. DCPCs to have conditional marker removed from Manual on WIS

Member State or Org	Centre	ID no.	CBS Endorsement	Principal GISC	WIS Manual action. 1) Remove conditional marker (*) from Manual on WIS 2) Add to Manual on WIS
Croatia	Croatia MMC	9	Endorsed	Offenbach	1) Remove conditional marker (*) from Manual on WIS
Czech Republic	RTH Prague	125	Endorsed	Offenbach	1) Remove conditional marker (*) from Manual on WIS
Italy	RTH Rome	97	Endorsed	Offenbach	1) Remove conditional marker (*) from Manual on WIS
Saudi Arabia	RTH Jeddah	13	Endorsed	Jeddah	1) Remove conditional marker (*) from Manual on WIS
Serbia	RCC Belgrade	147	Endorsed	Offenbach	1) Remove conditional marker (*) from Manual on WIS
Sweden	RTH Norrkoping	11	Endorsed	Offenbach	1) Remove conditional marker (*) from Manual on WIS
USA	WMC Washington (RTH)	G7	Endorsed	Washington	1) Remove conditional marker (*) from Manual on WIS

Table 2. DCPCs under review by CBS

Member State or Organization	Centre	ID no.	CBS Endorsement	Principal GISC	Recommendation
ACMAD	RCC	135	Awaiting information	Casablanca	3) Encouraged to complete certification
ACMAD	RSMC	134	Awaiting information	Casablanca	3) Encouraged to complete certification
Algeria	RTH Algiers	20	Awaiting information	Casablanca	3) Encouraged to complete certification
Argentina	RTH Buenos Aires	107	Under review	Brasilia	3) Encouraged to complete certification
Argentina	RSMC Buenos Aires	108	Under review	Brasilia	3) Encouraged to complete certification
Argentina	VAAC Buenos Aires	109	Under review	Brasilia	3) Encouraged to complete certification
Argentina	Regional Ozone Centre	110	Awaiting information	Brasilia	3) Encouraged to complete certification
Argentina	Regional Instrument Centre	111	Awaiting information	Brasilia	3) Encouraged to complete certification (Also needs CIMO endorsement)
Austria	RTH Vienna	166	Under review	Offenbach	3) Encouraged to complete certification
Brazil	Marine Meteorological Center	117	Awaiting information	Brasilia	3) Encouraged to complete certification (also needs JCOMM endorsement)
Egypt	RTH Cairo	2	Awaiting information	Casablanca	3) Encouraged to complete certification

Member State or Organization	Centre	ID no.	CBS Endorsement	Principal GISC	Recommendation
Egypt	RSMC Cairo	101	Awaiting information	Casablanca	3) Encouraged to complete certification
Egypt	RIC Cairo	102	Awaiting information	Casablanca	3) Encouraged to complete certification (Also needs CIMO endorsement)
Egypt	Regional Ozone Centre	103	Awaiting information	Casablanca	3) Encouraged to complete certification
Egypt	Regional Training Centre	104	Awaiting information	Casablanca	3) Encouraged to complete certification
Egypt	Regional Radiation Centre	105	Awaiting information	Casablanca	3) Encouraged to complete certification
Fiji	RSMC - TC	106	Awaiting information	Melbourne	3) Encouraged to complete certification
Finland	FMI-ARC	16	Awaiting information	Offenbach	3) Encouraged to complete certification
France	ODC Toulouse	124	Endorsed	Toulouse	2) Add to Manual on WIS
Germany	GRDC	47	Under review	Offenbach	3) Encouraged to complete certification
India	RSMC-TC	100	Awaiting information	New Delhi	3) Encouraged to complete certification
Indonesia	TCWC	-	Awaiting information	Melbourne	3) Encouraged to complete certification
Indonesia	NWP ATM SE ASIA	-	Awaiting information	Melbourne	3) Encouraged to complete certification
Indonesia	TRANSBOUNDARY FOREST FIRES	-	Awaiting information	Melbourne	3) Encouraged to complete certification
Indonesia	IO Tsunami Warning Centre	-	Awaiting information	Melbourne	3) Encouraged to complete certification
IODE	IODE Ocean Data Portal	119	Awaiting information	Exeter	3) Encouraged to complete certification
Italy	RSMC Rome	98	Under review	Offenbach	3) Encouraged to complete certification
JRC	GDACS	169	Under review	Offenbach	3) Encouraged to complete certification
Japan	NICT (Space Weather)	160	Endorsed	Tokyo	2) Add to Manual on WIS
Kenya	RTH Nairobi	6	Awaiting information	Offenbach	3) Encouraged to complete certification
Kenya	RSMC Nairobi	95	Awaiting information	Offenbach	3) Encouraged to complete certification
Kenya	RIC Nairobi	95	Awaiting information	Offenbach	3) Encouraged to complete certification (Also needs CIMO endorsement)
Morocco	RSMC	130	Awaiting information	Casablanca	3) Encouraged to complete certification
Morocco	RIC/RMIC	131	Awaiting information	Casablanca	3) Encouraged to complete certification (Needs CIMO and JCOMM endorsement)
Morocco	RSMC	132	Awaiting information	Casablanca	3) Encouraged to complete certification

Member State or Organization	Centre	ID no.	CBS Endorsement	Principal GISC	Recommendation
Netherlands	RCC De Bilt	21	Awaiting information	Exeter	3) Encouraged to complete certification
Netherlands	Satellite Centre De Bilt	78	Awaiting information	Exeter	3) Encouraged to complete certification
New Zealand	RSMC Wellington	13	Under review	Melbourne	3) Encouraged to complete certification
New Zealand	RTH Wellington	79	Under review	Melbourne	3) Encouraged to complete certification
New Zealand	VAAC Wellington	140	Under review	Melbourne	3) Encouraged to complete certification
Niger	RTH Niamey	26	Awaiting information	Casablanca	3) Encouraged to complete certification
Niger	AGRHYMET Niamey	27	Awaiting information	Casablanca	3) Encouraged to complete certification
Norway	Norwegian Institute for Air Research (NILU)	115	Awaiting information	Offenbach	3) Encouraged to complete certification
Qatar	Gulf Marine Center	146	Endorsed	Jeddah	2) Add to Manual on WIS
Russian Federation	Ocean Data Portal - Obninsk node	130	Awaiting information	Moscow	3) Encouraged to complete certification
Saudi Arabia	RSMC Jeddah	80	Awaiting information	Jeddah	3) Encouraged to complete certification
Saudi Arabia	RDMEC (Drought)	81	Awaiting information	Jeddah	3) Encouraged to complete certification
Senegal	RSMC Dakar	94	Awaiting information	Casablanca	3) Encouraged to complete certification
Senegal	RTH Dakar	4	Awaiting information	Casablanca	3) Encouraged to complete certification
Senegal	Dakar Aviation Data Centre	93	Awaiting information	Casablanca	3) Encouraged to complete certification
Spain	MEDARE	139	Endorsed	Toulouse	2) Add to Manual on WIS
Sweden	Baltrad	83	Awaiting information	Offenbach	3) Encouraged to complete certification
Sweden	IPY data repository	82	Withdrawn	Offenbach	Remove from Manual on WIS
Switzerland	GAWSIS (Switzerland)	145	Under review	Offenbach	3) Encouraged to complete certification]
Thailand	RTH Bangkok	5	Under review	Tokyo	3) Encouraged to complete certification
Turkey	RCC Turkey (EEMC)	162	Under review	Offenbach	3) Encouraged to complete certification
United Kingdom of Great Britain and Northern Ireland	ODC Exeter	123	Awaiting information	Exeter	3) Encouraged to complete certification
United Kingdom of Great Britain and Northern Ireland	BAS Cambridge	142	[Under review	Exeter	3) Encouraged to complete certification

Member State or Organization	Centre	ID no.	CBS Endorsement	Principal GISC	Recommendation
United Kingdom of Great Britain and Northern Ireland	VAAC London	137	Awaiting information	Exeter	3) Encouraged to complete certification
United Kingdom of Great Britain and Northern Ireland	WAFC London	136	Awaiting information	Exeter	3) Encouraged to complete certification
United States of America	COMET	144	Under review	Washington	3) Encouraged to complete certification
United States of America	NCAR	3	Under review	Washington	3) Encouraged to complete certification
United States of America	WAFC Washington	28	Awaiting information	Washington	3) Encouraged to complete certification
United States of America	RSMC Miami	29	Awaiting information	Washington	3) Encouraged to complete certification
United States of America	RSMC Honolulu	30	Awaiting information	Washington	3) Encouraged to complete certification
United States of America	NCEP	31	Awaiting information	Washington	3) Encouraged to complete certification
United States of America	ARL	32	Awaiting information	Washington	3) Encouraged to complete certification
United States of America	GOSIC	33	Awaiting information	Washington	3) Encouraged to complete certification
United States of America	NODC	34	Awaiting information	Washington	3) Encouraged to complete certification
United States of America	NGDC	35	Awaiting information	Washington	3) Encouraged to complete certification
United States of America	NESDIS	36	Awaiting information	Washington	3) Encouraged to complete certification
Uzbekistan	RTH Tashkent	18	Awaiting information	Seoul	3) Encouraged to complete certification

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Annex 3 to Recommendation 20 (CBS-Ext.(2014))

WMO INFORMATION SYSTEM COMPLIANCE

Additions to WMO-No. 1060 – Manual on WIS

1. Insert the following text into Part II of WMO-No. 1060 *Manual on the WMO Information System* relating to WIS Centres' compliance

2.5 Rolling review of WIS Centres

2.5.1 Background

The on-going performance of WIS relies on the continued compliance of WIS centres to agreed standards and practices. In order to ensure GISCs, DCPCs and NCs maintain their WIS compliance, centres should maintain a rolling review of their compliance with WIS standards and practices.

2.5.2 Responsibility

Members are responsible for maintaining compliance of centres with WIS standards and practices. CBS will oversee and support the rolling review processes with an aim to confirming a centre's compliance every eight years for NCs and DCPCs and every four years for GISCs.

2.5.3 Procedure

CBS will maintain guidelines for the rolling review of WIS centres in the Guide to the WMO Information System (WMO No 1061).

2. Modify the following text to Part IV of the WMO-No. 1060 *Manual on the WMO Information System* relating to WIS technical specifications

4.1 General

4.1.1 There are 15 technical specifications (WIS TechSpecs) that define the interfaces to the major WIS functions. The specifications for these interfaces are described in more detail in Appendix D and are named and numbered as follows:

…

4.1.6 The GTS file-naming convention shall be used for files and the associated metadata record whenever necessary. The GTS file-naming convention is documented in the *Manual on the Global Telecommunication System* (WMO-No. 386), Volume 1, Part II, Attachment II-15.

~~Note: The Guide to the WMO Information System (WMO-No. 1061), 4.1, references "WIS compliance specifications for GISCs, DCPCs and NCs", provided as supplementary guidance for WIS centres.~~

3. Insert the following text to introduce Appendix D, WMO-No. 1060 *Manual on the WMO Information System* relating to WIS technical specifications

APPENDIX D. WIS TECHNICAL SPECIFICATIONS

WIS-TechSpec-1, Uploading of Metadata for Data and Products

Applicable Standards	content: ISO 19115, WMO Core Metadata Profile file naming convention (associates file to its metadata): documented in GTS Manual, Vol. 1, Part II, Attachment II-15 communication: TBD by host of DAR Metadata Catalogue (typical communication types are listed below)
Communication Types	terminal-host; store-and-forward or file transfer client-server; request-response (e.g., HTTP Post)
Service Level Required	mix of dedicated and public services
Network Transports and Supporting Services	various transports, which may include encryption (TBD as needed for connection to host server)
Performance Metrics DAR Metadata	must be transmitted prior to the file associated with the metadata
Use Cases	WIS Technical Specification Appendix E Use Cases: B.1, Provide Metadata for Data or Product

WIS Requirements (in addition to requirements applicable to all interfaces)	provide metadata catalogue across all GISCs of data, products, and services; assure catalogue interoperability using ISO 23950 search and geospatial services; catalogue WIS contributions in GEOSS Clearinghouse; use ISO 19115 and the WMO core metadata profile; standardize practices for electronic archival of metadata; provide metadata with quality indications to enable search, retrieval, and archiving; use ISO standards for references to specific places on the Earth; draw on existing Spatial Data Infrastructure (SDI) components as institutional and technical precedents; [each DCPC] implements backup and recovery of essential services; use dedicated telecommunications and public Internet for timely delivery; [each GISC] receives from NCs and DCPCs within its area of responsibility the data and products intended for global exchange
Notes:	This interface builds on existing GTS practice, adding the particular standard format for WIS metadata about data, products, and services. For updating the DAR Metadata Catalogue, WIS Centres should support two kinds of maintenance facilities: a file upload facility for "batch" updating (add, replace, or delete metadata records treated as separate files); and an online form for changing metadata entries in the DAR Metadata Catalogue (add, change, or delete of elements in a record as well as whole records). WIS Centres need to maintain the updated DAR Metadata Catalogue as a searchable resource offered to all authorized searchers (see WIS-TechSpec-8). WIS Centres are required to communicate all changes to each physically distributed part of the logically centralized DAR Metadata Catalogue (see WIS-TechSpec-9).

WIS-TechSpec-2, Uploading of Data and Products

Applicable Standards	GTS Manual, A.II-2 and other WMO manual(s), specific to programmes file naming convention (associates file to its metadata): documented in GTS Manual, Vol. 1, Part II, Attachment II-15
Communication Types	terminal-host; store-and-forward or file transfer client-server; request-response
Service Level Required	dedicated bandwidth and high reliability
Network Transports and Supporting Services	GTS public or private Internet using TCP/IP with encryption
Performance Metrics products and data	must be handled as specified in Part I, 1.3 Design Principles of the GTS [GTS-Manual], and other WMO manual(s), specific to programmes
Use Cases	WIS Technical Specification Appendix E Use Cases: B.2, Upload Data or Product to DCPC or GISC
WIS Requirements (in addition to requirements applicable to all interfaces)	make WMO Resolution 40 data available through GEOSS interoperable arrangements; use ISO standards for references to specific places on the Earth; harmonize data formats, transmission, archiving and distribution across disciplines; [each DCPC] implements backup and recovery of essential services; use WWW communication links for high priority real-time data; use dedicated telecommunications for the collection and dissemination of time-critical and operation-critical data and products; support rapid access and integration of real-time and non real-time (archive) data sets; identify and use a variety of data types across WMO programmes; [each NC] collects national data; [each NC] generates and disseminates products for national use; [each NC] uploads data and products intended for global exchange to its associated GISC (and DCPC where applicable); [each DCPC] collects programme-specific data and products; [each DCPC] collects the data and products intended for dissemination to NCs within its area of responsibility; [each DCPC] uploads data and products intended for global exchange to its associated GISC; [each GISC] receives from NCs and DCPCs within its area of responsibility the data and products intended for global exchange
Notes	This interface builds on existing GTS practice, supplemented with other file transfer mechanisms such as the Internet. Although it is required that data arrives only after its associated metadata, a grace period of two minutes is allowed before the data file is regarded as erroneous.

WIS-TechSpec-3, Centralization of Globally Distributed Data

Applicable Standards	GTS Manual, Attachment I-3

Communication Types	terminal-host; store-and-forward or file transfer
Service Level Required	dedicated bandwidth and high reliability
Network Transports and Supporting Services	GTS
Performance Metrics global information	some of the operation-critical data intended for global distribution is to be transmitted end-to-end within two minutes
Use Cases	WIS Technical Specification Appendix B Use Cases: B.4, Manage Cache of Data across GISCs
WIS Requirements (in addition to requirements applicable to all interfaces)	standardize practices for electronic archival of metadata; harmonize data formats, transmission, archiving and distribution across disciplines; [each GISC] exchanges with other GISCs the data and products intended for global exchange; [each GISC] provides coordination and mutual backup with other GISCs; [each GISC] holds the data and products intended for global exchange for at least 24 hours; use dedicated telecommunications for the collection and dissemination of time-critical and operation-critical data and products; support rapid access and integration of real-time and non real-time (archive) data sets; identify and use a variety of data types across WMO programmes; [each GISC] receives from NCs and DCPCs within its area of responsibility the data and products intended for global exchange; [each GISC] disseminates the data and products intended for global exchange within its area of responsibility.
Notes	The set of WMO data and products required to be cached for 24 hours at the GISCs is that designated as "intended for global dissemination". This does not encompass all of the material handled by IGDDS. Although the cache of data and products intended for global distribution generally is required to be current across all GISCs to within 15 minutes, operation-critical data such as hazard warnings must be current to within two minutes. The cache size is expected to grow from one gigabyte per day. The cache needs to be highly accurate and the system for logical centralization needs to be affordable and robust; single points of failure and complex procedures are not acceptable. At this point in WIS system design, multiple methods can be envisioned for centralizing the distributed cache. One approach is that all of the GISCs would be subscribed to receive all message traffic. For performance efficiency with adequate redundancy among up to ten GISCs, GISC subscriptions would be arranged in up to three tiers.

WIS-TechSpec-4, Maintenance of User Identification and Role Information

Applicable Standards	standards for content and communications are TBD by host of identification and role information database
Communication Types	terminal-host; store-and-forward or file transfer (e.g., FTP, HTTP) client-server; request-response (e.g., HTTP with CGI Web form)
Service Level Required	non-dedicated shared network may be used, provided there is privacy protection for identified individuals as required by national laws
Network Transports and Supporting Services	public or private Internet using TCP/IP with encryption; typically HTTP with GET or POST methods, and may include SOAP
Performance Metrics identification and role information	the timeliness of changes to user identification and role information is application-specific and subject to NC or DCPC procedures
Use Cases	WIS Technical Specification Appendix B Use Cases: B.5, Maintain Identification and Role Information for WIS Users
WIS Requirements (in addition to requirements applicable to all interfaces)	use ISO standards for references to specific places on the Earth; harmonize data formats, transmission, archiving and distribution across disciplines; [each NC] authorizes its national users to access WIS; [each DCPC] supports access to data and products via Internet request/reply; [each DCPC] implements backup and recovery of essential services; use dedicated telecommunications and public Internet for timely delivery; identify and use a variety of data types across WMO programmes

Notes	For updating the identification and role information concerning candidate or current users of WIS, WIS Centres should support two kinds of maintenance facilities: a file upload facility for "batch" updating (add, replace, or delete identification and role records treated as separate files); and an online form for changing individual identification and role entries (add, change, or delete of elements in a record as well as whole records).

WIS-TechSpec-5, Consolidated View of Distributed Identification and Role Information

Applicable Standards	TBD by host of particular identification and role information collection (typical communication types are listed below)
Communication Types	terminal-host; store-and-forward or file transfer client-server; request-response (e.g., HTTP Post)
Service Level Required	mix of dedicated and public services, provided there is privacy protection for identified individuals as required by national laws
Network Transports and Supporting Services	various transports, which may include encryption (TBD as needed for connection to host server)
Performance Metrics currency	collections of user identification and role information should be current to intervals no more than half the currency required by the affected WIS Centres (see WIS-TechSpec-4)
Use Cases	WIS Technical Specification Appendix B Use Cases: B.5, Maintain Identification and Role Information for WIS Users
WIS Requirements (in addition to requirements applicable to all interfaces)	use ISO standards for references to specific places on the Earth; harmonize data formats, transmission, archiving and distribution across disciplines; draw on existing Spatial Data Infrastructure (SDI) components as institutional and technical precedents; [each NC] authorizes its national users to access WIS; [each DCPC] implements backup and recovery of essential services; [each GISC] provides coordination and mutual backup with other GISCs; use dedicated telecommunications and public Internet for timely delivery; identify and use a variety of data types across WMO programmes
Notes	Administrators of authentication and authorization at WIS Centres need to share updated identification and role information as a resource available across WIS Centres. Yet, it is necessary to prevent the inappropriate disclosure of any personally identifiable information. This aspect is complicated by the requirement for international data access to make use of authentication mechanisms at the level of national organizations. At this point in WIS system design, mechanisms have not been decided for handling identification and role information as needed across WIS centres.

WIS-TechSpec-6, Authentication of a User

Applicable Standards	standards used by commercial, off-the-shelf authentication software; may include PKI (public key infrastructure)
Communication Types	client-server; request-response; stateless transaction
Service Level Required	dedicated bandwidth and high reliability, including privacy protection for identified individuals as required by national laws
Network Transports and Supporting Services	public or private Internet using TCP/IP with encryption
Performance Metrics Response Time Request Rate Concurrency	maximum: 2 seconds per authentication request minimum: 40 authentication requests per second minimum: 20 active sessions
Use Cases	WIS Technical Specification Appendix B Use Cases: B.5, Maintain Identification and Role Information for WIS Users
WIS Requirements (in addition to requirements applicable to all interfaces)	harmonize data formats, transmission, archiving and distribution across disciplines; [each NC] authorizes its national users to access WIS; [each DCPC] implements backup and recovery of essential services; [each GISC] provides coordination and mutual backup with other GISCs; use WWW communication links for high priority real-time data; use dedicated telecommunications and public Internet for timely delivery

Notes	The client sends to the authentication server an authentication request for a particular user whose identification and credentials are included in the request. The authentication server references the consolidated identification and role information resource for WIS and returns an authentication response. That response either confirms or denies that the identified user has provided sufficient credentials.

WIS-TechSpec-7, Authorization of a User Role

Applicable Standards	standards used by governments for user authorization software
Communication Types	client-server; request-response; stateless transaction
Service Level Required	dedicated bandwidth and high reliability
Network Transports and Supporting Services	public or private Internet using TCP/IP with encryption
Performance Metrics Response Time Request Rate Concurrency	maximum: 2 seconds per authorization request minimum: 40 authorization requests per second minimum: 20 active sessions
Use Cases	WIS Technical Specification Appendix B Use Cases: B.5, Maintain Identification and Role Information for WIS Users
WIS Requirements (in addition to requirements applicable to all interfaces)	harmonize data formats, transmission, archiving and distribution across disciplines; [each NC] authorizes its national users to access WIS; [each DCPC] implements backup and recovery of essential services; [each GISC] provides coordination and mutual backup with other GISCs; use WWW communication links for high priority real-time data; use dedicated telecommunications and public Internet for timely delivery
Notes	The client sends to the authorization server an authorization request for a particular user whose identification is included in the request. The authorization server references the consolidated identification and role information resource for WIS and returns an authorization response. That response either contains a list of the authorised roles for the user or denies that the identified user has any authorised roles.

WIS-TechSpec-8, DAR Catalogue Search and Retrieval

Applicable Standards	ISO 23950 Information Search and Retrieval Protocol [ISO-23950] including GEO Profile and SRU (Search and Retrieve via URL) Profile WMO Core Profile of the ISO Metadata Standard [IPET-MI(07)]
Communication Types	client-server; request-response
Service Level Required	non-dedicated shared network
Network Transports and Supporting Services	public or private Internet using TCP/IP which may include encryption; typically HTTP with GET or POST methods, and may include SOAP
Performance Metrics Response Time Search Request Rate Concurrency	maximum: 2 seconds per request minimum: 40 keyword and bounding box searches per second minimum: 20 active sessions
Applicable Use Cases	WIS Technical Specification Appendix B, Use Case: B.6, Discover Data or Products

WIS Requirements (in addition to requirements applicable to all interfaces)	provide metadata catalogue across all GISCs of data, products, and services; assure catalogue interoperability using ISO 23950 search and geospatial services; catalogue WIS contributions in GEOSS Clearinghouse; use ISO 19115 and the WMO core metadata profile; standardize practices for electronic archival of metadata; provide metadata with quality indications to enable search, retrieval, and archiving; make WMO Resolution 40 data available through GEOSS interoperable arrangements; use ISO standards for references to specific places on the Earth; harmonize data formats, transmission, archiving and distribution across disciplines; draw on existing Spatial Data Infrastructure (SDI) components as institutional and technical precedents; [each DCPC] supports access to data and products via Internet request/reply; [each DCPC] implements backup and recovery of essential services; [each GISC] provides coordination and mutual backup with other GISCs; use public Internet for Data Discovery, Access and Retrieval; support rapid access and integration of real-time and non real-time (archive) data sets; identify and use a variety of data types across WMO programmes; support WIS as a GEOSS component with a core role
Notes	The procedures for designation of a GISC or DCPC require that both type of WIS centre maintain data, product and service catalogues in the WMO-agreed standard format and facilitate access to these catalogues. Therefore, network services should be treated as a type of WIS product that can be discovered through the DAR catalogue.

WIS-TechSpec-9, Consolidated View of Distributed DAR Metadata Catalogues

Applicable Standards	TBD by host of particular DAR Metadata Catalogue instance (typical communication types are listed below)
Communication Types	terminal-host; store-and-forward or file transfer client-server; request-response (e.g., HTTP Post)
Service Level Required	mix of dedicated and public services
Network Transports and Supporting Services	various transports, which may include encryption (TBD as needed for connection to host server)
Performance Metrics currency	distributed instances of DAR Metadata should not diverge in content by more than one day
Use Cases	WIS Technical Specification Appendix B Use Cases: B.6, Discover Data or Products
WIS Requirements (in addition to requirements applicable to all interfaces)	provide metadata catalogue across all GISCs of data, products, and services; assure catalogue interoperability using ISO 23950 search and geospatial services; catalogue WIS contributions in GEOSS Clearinghouse; use ISO 19115 and the WMO core metadata profile; standardize practices for electronic archival of metadata; provide metadata with quality indications to enable search, retrieval, and archiving; make WMO Resolution 40 data available through GEOSS interoperable arrangements; use ISO standards for references to specific places on the Earth; harmonize data formats, transmission, archiving and distribution across disciplines; draw on existing Spatial Data Infrastructure (SDI) components as institutional and technical precedents; [each DCPC] supports access to data and products via Internet request/reply; [each DCPC] implements backup and recovery of essential services; [each GISC] provides coordination and mutual backup with other GISCs; use public Internet for Data Discovery, Access and Retrieval; support WIS as a GEOSS component with a core role
Notes	At this point in WIS system design, multiple methods can be envisioned for logically centralizing the physically distributed DAR Metadata Catalogue. At a meeting of the ET-WISC (Geneva, 2010), the first set of GISCs decided to use OAI-PMH version 2.0 initially.

WIS-TechSpec-10, Downloading Files via Dedicated Networks

Applicable Standards	GTS Manual, A.II-2 and other WMO manual(s), specific to programmes
Communication Types	terminal-host; file transfer broadcast or multicast client-server; publish-subscribe or request-response
Service Level Required	dedicated bandwidth and high reliability

Network Transports and Supporting Services	GTS IGDDS satellite broadcast (radio or television frequencies) public or private Internet using TCP/IP with encryption
Performance Metrics operation-critical data	must be handled as specified in Part I, 1.3 Design Principles of the GTS [GTS-Manual], and other WMO manual(s), specific to programmes
Use Cases	WIS Technical Specification Appendix B Use Cases: B.7, Ad Hoc Request for Data or Product ("Pull") B.8, Subscribe to Data or Product ("Push") B.9, Download Data or Product from WIS Centre
WIS Requirements (in addition to requirements applicable to all interfaces)	harmonize data formats, transmission, archiving and distribution across disciplines; draw on existing Spatial Data Infrastructure (SDI) components as institutional and technical precedents; [each DCPC] supports access to data and products via Internet request/reply; [each GISC] provides coordination and mutual backup with other GISCs; [each GISC] holds the data and products intended for global exchange for at least 24 hours; use WWW communication links for high priority real-time data; use dedicated telecommunications for the collection and dissemination of time-critical and operation-critical data and products; support rapid access and integration of real-time and non real-time (archive) data sets; identify and use a variety of data types across WMO programmes; [each NC] generates and disseminates products for national use; [each DCPC] disseminates data and products intended for regional exchange; [each GISC] disseminates the data and products intended for global exchange within its area of responsibility
Notes	

WIS-TechSpec-11, Downloading Files via Non-dedicated Networks

Applicable Standards	WMO manual(s), specific to programmes
Communication Types	terminal-host; file transfer broadcast or multicast client-server; publish-subscribe or request-response
Service Level Required	non-dedicated shared network
Network Transports and Supporting Services	IGDDS satellite broadcast (radio or television frequencies) public or private Internet using TCP/IP which may include encryption
Performance Metrics	GTS Manual, Vol. 1, Part II, Attachment II-15, or as otherwise specified in WMO manual(s), specific to programmes (non-dedicated network should not be used for operation-critical data)
Use Cases	WIS Technical Specification Appendix B Use Cases: B.7, Ad Hoc Request for Data or Product ("Pull") B.8, Subscribe to Data or Product ("Push") B.9, Download Data or Product from WIS Centre
WIS Requirements (in addition to requirements applicable to all interfaces)	harmonize data formats, transmission, archiving and distribution across disciplines; [each DCPC] supports access to data and products via Internet request/reply; [each GISC] provides coordination and mutual backup with other GISCs; [each GISC] holds the data and products intended for global exchange for at least 24 hours; use dedicated telecommunications and public Internet for timely delivery; use public Internet for Data Discovery, Access and Retrieval; support rapid access and integration of real-time and non real-time (archive) data sets; identify and use a variety of data types across WMO programmes; [each NC] generates and disseminates products for national use; [each DCPC] disseminates data and products intended for regional exchange; [each GISC] disseminates the data and products intended for global exchange within its area of responsibility
Notes	

WIS-TechSpec-12, Downloading Files via Other Methods

Applicable Standards	WMO manual(s), specific to programmes
Communication Types	facsimile, shipping of physical media, etc.
Service Level Required	priority delivery for operation-critical data

Network Transports and Supporting Services	various
Performance Metrics operation-critical data other data/products	must be handled as specified in Part I, 1.3 Design Principles of the GTS [GTS-Manual], and other WMO manual(s), specific to programmes as specified in WMO manual(s), specific to programmes
Use Cases	WIS Technical Specification Appendix B Use Cases: B.7, Ad Hoc Request for Data or Product ("Pull") B.8, Subscribe to Data or Product ("Push") B.9, Download Data or Product from WIS Centre
WIS Requirements (in addition to requirements applicable to all interfaces)	provide metadata with quality indications to enable search, retrieval, and archiving; harmonize data formats, transmission, archiving and distribution across disciplines; draw on existing Spatial Data Infrastructure (SDI) components as institutional and technical precedents; [each DCPC] supports access to data and products via Internet request/reply; [each DCPC] implements backup and recovery of essential services; [each GISC] provides coordination and mutual backup with other GISCs; [each GISC] holds the data and products intended for global exchange for at least 24 hours; identify and use a variety of data types across WMO programmes; [each NC] generates and disseminates products for national use; [each DCPC] disseminates data and products intended for regional exchange; [each GISC] disseminates the data and products intended for global exchange within its area of responsibility
Notes	

WIS-TechSpec-13, Maintenance of Dissemination Metadata

Applicable Standards	standards for content and communications are TBD by host of Dissemination Metadata database
Communication Types	terminal-host; store-and-forward or file transfer client-server; request-response (e.g., HTTP with CGI Web form)
Service Level Required	mix of dedicated and public services
Network Transports and Supporting Services	public or private Internet using TCP/IP which may include encryption; typically HTTP with GET or POST methods, and may include SOAP
Performance Metrics dissemination metadata changes	GTS has required that requests for changes to dissemination metadata are submitted 2 months before delivery is to begin
Use Cases	WIS Technical Specification Appendix B Use Cases: B.10, Provide Dissemination Metadata
WIS Requirements (in addition to requirements applicable to all interfaces)	provide metadata with quality indications to enable search, retrieval, and archiving; use ISO standards for references to specific places on the Earth; harmonize data formats, transmission, archiving and distribution across disciplines; [each DCPC] implements backup and recovery of essential services; [each GISC] provides coordination and mutual backup with other GISCs; use WWW communication links for high priority real-time data; use dedicated telecommunications for the collection and dissemination of time-critical and operation-critical data and products; use dedicated telecommunications and public Internet for timely delivery; support rapid access and integration of real-time and non real-time (archive) data sets; [each NC] generates and disseminates products for national use; [each NC] uploads data and products intended for global exchange to its associated GISC (and DCPC where applicable); [each DCPC] disseminates data and products intended for regional exchange; [each DCPC] uploads data and products intended for global exchange to its associated GISC; [each GISC] disseminates the data and products intended for global exchange within its area of responsibility

Notes	For updating the Dissemination Metadata, WIS Centres should support two kinds of maintenance facilities: a file upload facility for "batch" updating (add, replace, or delete metadata records treated as separate files); and an online form for changing individual entries (add, change, or delete of elements in a record as well as whole records). WIS Centres are required to communicate all changes to each physically distributed part of the logically centralized Dissemination Metadata (see WIS-TechSpec-14). The plan is for population of the DAR Metadata to be accomplished centrally, based on an offer from Meteo France to generate DAR metadata from Volume C1 of WMO Publication No. 9. Because full transition of WMO centres to the new metadata will occur over some time, procedures are required to assure that changes to either set of metadata are reflected in both.

WIS-TechSpec-14, Consolidated View of Distributed Dissemination Metadata Catalogues

Applicable Standards	TBD by host of particular dissemination metadata collection (typical communication types are listed below)
Communication Types	terminal-host; store-and-forward or file transfer client-server; request-response (e.g., HTTP Post)
Service Level Required	mix of dedicated and public services
Network Transports and Supporting Services	various transports, which may include encryption (TBD as needed for connection to host server)
Performance Metrics currency	distributed instances of dissemination metadata should not diverge in content by more than one week
Use Cases	WIS Technical Specification Appendix B Use Cases: B.10, Provide Dissemination Metadata
WIS Requirements (in addition to requirements applicable to all interfaces)	provide metadata catalogue across all GISCs of data, products, and services; provide metadata with quality indications to enable search, retrieval, and archiving; harmonize data formats, transmission, archiving and distribution across disciplines; [each DCPC] implements backup and recovery of essential services; [each GISC] provides coordination and mutual backup with other GISCs; use WWW communication links for high priority real-time data; use dedicated telecommunications for the collection and dissemination of time-critical and operation-critical data and products; use dedicated telecommunications and public Internet for timely delivery; support rapid access and integration of real-time and non real-time (archive) data sets; identify and use a variety of data types across WMO programmes; [each NC] uploads data and products intended for global exchange to its associated GISC (and DCPC where applicable); [each DCPC] disseminates data and products intended for regional exchange; [each DCPC] uploads data and products intended for global exchange to its associated GISC; [each GISC] disseminates the data and products intended for global exchange within its area of responsibility
Notes	Dissemination Metadata as updated at WIS Centres must be available across WIS Centres. At this point in WIS system design, mechanisms have not been decided for how this sharing will be accomplished.

WIS-TechSpec-15, Reporting of Quality of Service

Applicable Standards	standards for content and communications are TBD by host of centralized reporting database
Communication Types	terminal-host; store-and-forward or file transfer (e.g., FTP, HTTP) client-server; request-response (e.g., HTTP with CGI Web form)
Service Level Required	non-dedicated shared network
Network Transports	public or private Internet using TCP/IP which may include encryption; typically HTTP with GET or POST methods, and may include SOAP
Performance Metrics reports	sent on a schedule determined by the centralized reporting manager based on the needs of WIS Centres
Use Cases	WIS Technical Specification Appendix B Use Cases: B.11, Report Quality of Service across WIS Centres

WIS Requirements (in addition to requirements applicable to all interfaces)	use ISO standards for references to specific places on the Earth
Notes	As noted in Use Case B.11, agreements on service levels can be anticipated eventually for WIS operations. These should include data and network security as well as performance and reliability. Although not yet addressed in WIS system design, performance reports can be generated efficiently by having each WIS Centre upload its reports to a single analysis site within a fixed time window.

Recommendation 21 (CBS-Ext.(2014))

UPDATES TO THE *GUIDE TO THE WMO INFORMATION SYSTEM* (WMO-No. 1061)

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 14 (EC-65) – Quality management and infrastructure development of the WMO Information System,

(2) The *Manual on the WMO Information System* (WMO-No. 1060),

(3) The *Guide to the WMO Information System* (WMO-No. 1061),

(4) The *Technical Regulations* (WMO-No. 49), Volume I, Part II, section 5 – Competence of Meteorological, Hydrological and Climatological Personnel,

Recommends the following modifications to the *Guide to the WMO Information System*:

(1) To add Part VI on Operational Guidance as described in Annex 1 to the present recommendation;

(2) To add an appendix containing annexes to paragraphs within the Guide, as described in Annex 2 to the present recommendation;

(3) To add an appendix containing Use Cases supporting the Technical Specifications of the WMO Information System (WIS) provided in the *Manual on the WMO Information System*, as described in Annex 3 to the present recommendation;

(4) To add an appendix containing Demonstration Test Cases supporting the WIS centre demonstration process for Global Information System Centres, Data Collection or Production Centres and National Centres, as described in Annex 4 to the present recommendation;

Further recommends to add the WIS Competencies, as contained in Annex 5 to the present recommendation, and WIS Training and Learning Guide, as contained in Annex 6 to the present recommendation, to the *Technical Regulations*, Volume I, Part II, section 5;

Encourages Members to use, in the interim, the WIS Competencies and WIS Training and Learning Guide described in Annexes 5 and 6 to the present recommendation;

Requests the Secretary-General to prepare appropriate text for inclusion in the Manual and the Guide linking the WIS Competencies and WIS Training and Learning Guide to the *Technical*

Regulations, Volume I, Part II, section 5 – Competence of Meteorological, Hydrological and Climatological Personnel.

Annex 1 to Recommendation 21 (CBS-Ext.(2014))

WMO INFORMATION SYSTEM OPERATIONAL GUIDANCE – NEW PART VI

1. Insert the following text to introduce Part VI of the *Guide to the WMO Information System* (WMO-No. 1061) relating to WIS operational practices

PART VI. OPERATIONAL GUIDANCE

6.1 General

The *Manual on the WMO Information System* defines practices and procedures based on specific standards defined in Part IV of the Manual that are to be used by centres contributing to WIS. Part VI of this Guide to the WMO Information System is being developed and will contain information on the agreed operational practices that are considered to be stable and slow changing. Other guidance on agreed or recommended practices for WIS centres may be found at http://wis.wmo.int/WIS_Operations.

6.2 GISC support to NCs and DCPCs

6.2.1 A GISC is expected to provide the following support activities to the centres (NCs and DCPCs) in its area of responsibility.

Operation coordination

6.2.2 Each GISC should organize regular meetings with the WIS National and WIS Centre Focal Points for those centres belonging to its AMDCN to coordinate the implementation, operation and improvement of the AMDCN to ensure it meets WIS requirements.

6.2.3 Each GISC should maintain business continuity plans and handover arrangements to ensure continued service to the NCs and DCPCs in its area of responsibility, especially for the collection and distribution of data and products.

Technical support

6.2.4 Each GISC should provide technical consultation on implementing and improving WIS functionality, such as search and management of metadata, to the centres in its area of responsibility.

6.2.5 Each GISC should support the centres in its area of responsibility in creating and maintaining WIS discovery metadata, in adopting recommended data formats as well as in monitoring activities.

Capacity-building support

6.2.6 Each GISC should develop and provide training courses with reference to the WIS Competencies and the WIS Training and Learning Guide to meet the capacity-development requirements of the centres in its area of responsibility.

6.3 GISC back-up procedures

6.3.1 Paragraph 3.5.9.2 of WMO No. 1060 Manual on WIS requires GISCs to maintain arrangements with one or more back-up GISCs that include, as a minimum, the collection and dissemination of information to/from its AMDCN to be taken up by another GISC in case of an incapacitating system failure.

Note: Responsibilities of the backup GISC are limited to those centres allocated to it in the backup agreement between the GISC and its backup GISC.

Backup Services

6.3.2 Data collection and distribution must continue without interruption to and from centres in the GISC area being backed up. Where a centre's routine receipt of data is through subscription (e.g. GTS push), the backup GISC must have a current list of data to be sent to each centre or provide a place for the centres to come and get the data (e.g. GISC Cache).

6.3.3 Centres may be unable to change their GTS subscriptions during a period of back up operation, and any changes to subscriptions might not be maintained when normal operations resume.

6.3.4 Changes to metadata will not be possible during a back-up period

6.3.5 Any ad hoc changes made during a back-up period may need to be redone after return to normal operations.

User Information

6.3.6 If there is a need to exchange user information between GISCs in support of backup, proper security measures should be taken based on the agreement on the two GISCs. However, the centres should ensure that the backup GISC has sufficient information for sending and collecting data from centres being supported during a back-up period.

6.3.7 Ad hoc changes to subscriptions, including additions or deletions of subscribers should be avoided while in backup mode. Any ad hoc changes made during a backup period may need to be redone after return to normal operations.

Networks

6.3.8 GISCs need to ensure network connectivity to centres in the AMDCN of the GISC it is backing up. This may be through dedicated links, such as GTS, or over the Internet. Such connectivity should be in line with the Guide to IT Security (WMO No 1115) and Guide on VPN via the Internet (WMO No 1116) as applicable.

6.4 Procedures for changing principal GISC

6.4.1 The principal GISC for each centre is listed in Appendix B of WMO No. 1060 Manual on WIS. The recommended procedure for NCs and DCPCs changing their principal GISC is provided in the Annex to this Paragraph (See Appendix A).

6.4.2 Once notified that the new principal GISC is ready, the centre shall start using the WIS services of the new principal GISC, in particular the service of uploading and managing the WIS discovery metadata for its data and products.

6.5 Guidelines for migrating WIS discovery metadata records from one GISC to another GISC

6.5.1 A side effect of Section 4.10 of WMO No. 1060 Manual on WIS that defines how GISCs should exchange metadata is that any NC or DCPC can upload its metadata records only to its principal GISC. Not applying this rule will lead unnecessary duplication of WIS discovery metadata.

The annex to this paragraph (see Appendix A) describes the agreed procedures that a centre and affected GISCs should follow in the cases of a centre changing its principal GISC.

6.5.2 The principles defined in the Annex to paragraph 6.5.1 can also apply to a GISC providing temporary back-up metadata management services to a centre's principal GISC.

6.6 Procedure on rolling review of WIS centres

6.6.1 Sections 2.2.4 and 2.3.4 of WMO No. 1060 Manual on WIS define how GISCs and DCPCs are required to demonstrate to CBS their capability to provide WIS services in compliance with the GISC or DCPC functions and responsibilities.

6.6.2 CBS, recognizing that for WIS to remain fully functional, requires regular reviews of each NC, DCPC and GISC ensuring their on-going compliance with the Manual on WIS. Recommended practices for this rolling review process are provided in the Annex to this paragraph (see Appendix-A).

Annex 2 to Recommendation 21 (CBS-Ext.(2014))

WMO INFORMATION SYSTEM OPERATIONAL GUIDANCE – NEW APPENDIX A

1. Insert the following Appendix A of the *Guide to the WMO Information System* (WMO-No. 1061) containing annexes to paragraphs in the Guide

APPENDIX A. ANNEXES TO PARAGRAPHS IN THE GUIDE TO THE WMO INFORMATION SYSTEM

Note: The following annexes to paragraphs in the Guide to WIS are labelled in the form of Paragraph Number/Annex number.

6.4.1 / Annex 1 – Procedures for changing of principal GISC

1. The centre (NC/DCPC) wishing to change its principal GISC should consult with its present and proposed principal GISCs and receive the agreement of the new principal GISC.

2. The centre should liaise with the chosen GISC to check the communication network connectivity to the chosen GISC and ensure that the bandwidth is sufficient to send and receive all data without undue delays.

3. The centre should send a letter endorsed by its Permanent Representative to the WMO Secretary-General, with a copy to its existing GISC. The letter should state the centre's choice of new principal GISC and include endorsement of the arrangement by the new principal GISC. The letter should also ask the Secretary-General to inform the regional association responsible for the centre (and those of the GISCs concerned where they are not in the same region as the centre).

4. The WMO secretariat shall inform CBS, with copy to the original and new principal GISC of the change to prepare an update to WMO No. 1060 Manual on WIS Appendix B.

5. WMO secretariat should update the WIS centres Database (http://wis.wmo.int/wiscentresdb) and the WMO Country Profile Database (http://www.wmo.int/cpdb).

6. The new principal GISC should coordinate with the associated GISC (s) for the centre to arrange and setup the backup service.

7. The new Principal GISC should coordinate with the original principal GISC to take over responsibility for discovery metadata records describing the data and products of the centre as recommended in section 6.5 of this Guide to the WIS.

8. The new principal GISC should notify all operational GISCs of the change to its area of responsibility.

6.5.1 / Annex 1 – Guidelines for migrating metadata records from one GISC to another GISC

1. Scenario and use case

1.1 Consider the migration of metadata between two GISCs: GISC A and GISC B. GISC B is becoming newly operational and starting metadata management for National Centre X as its principal GISC. Accordingly, GISC A, which has been providing the WIS Interim Metadata Management Service (WIMMS) for National Centre X, is ending the service. Practically, a set of metadata records owned by National Centre X needs to be moved from the OAI set that is provided by GISC A (labelled in what follows as WIS-GISC-A) to that of provided by GISC B (WIS-GISC-B).

2. Operational guidelines

2.1. Give notice to other GISCs

GISC A and B jointly give one-week prior notice to other operational GISCs that they will transfer the metadata management from GISC A to B, with the list of location identifiers CCCC, in case of metadata records that are associated with GTS messages. This notification is necessary because other GISCs need to make configuration changes so that each CCCC belongs to specific OAI sets, before they start harvesting new records.

2.2. Delete and add records at GISC A and B

A) GISC A – delete records from WIS-GISC-A
This should be done using the “deleted records” procedures in OAI-PMH, not the simple deletion of records from the database, so that harvesters of other GISCs can harvest the deletion information through the ordinary incremental harvesting. The specifications for deleted records are described in section 2.5.1 of The Open Archives Initiative Protocol for Metadata Harvesting (http://wis.wmo.int/oaiprotocol).

In the case that GISC A needs to delete these records completely from its database, GISC A must only do so after it makes sure that other GISCs have completed harvesting the deletion.

B) GISC B – add records to WIS-GISC-B set
This should be done with an accurate datestamp, which allows harvesters of other GISCs to gain the added records through the ordinary incremental harvesting.

2.3. Track harvesting by other GISC

GISC A and B make sure that other GISCs harvest the change correctly, and if not they need to give notice and ask for manual adjustments.

3. References

- OAI metadata harvesting protocol: http://wis.wmo.int/oaiprotocol

6.6.2/ Annex 1 – Procedure for rolling review of WIS centres

Note: In the event that the structure of CBS changes, all references to Open Area Programme Group (OPAG), Implementation Coordination Team (ICT), Expert Team (ET) or Task Team (TT) are intended to apply to successors of the named bodies.

1. Requirement: WIS Centres must comply with WMO No. 1060 Manual on WIS

a) The Commission for Basic Systems (CBS) is responsible for certification of WIS Centres' compliance with WIS specifications. CBS will maintain, within its OPAG ISS (or its successor) structure, a task team to coordinate WIS centre audits and certifications. For the purpose of this Guide, this task team or its equivalent group of experts is referred to in the following guidelines as the TT-CAC.

i) GISCs
(1) TT-CAC, on behalf of CBS, is responsible for audit and certification of GISCs

ii) DCPCs
(1) DCPCs are to be certified by the TT-CAC
(2) Where a DCPC is not using the infrastructure of its principal GISC, and its principal GISC is operational, then it can be certified by TT CAC once the principal GISC has performed the tests; however, if the principal GISC is not operational, TT-CAC will arrange for a suitable GISC to perform the tests;
(3) If a DCPC uses the infrastructure of its principal GISC then it is certified as a part of the GISC audit certification.

iii) NCs
(1) Compliance of NCs is the responsibility of the PR
(2) Testing of compliance of an NC should be done by its principal GISC.
(3) TT-CAC will monitor the NC compliance process in consultation with NCs and GISCs

b) WIS technical specifications are recorded in Appendix C of WMO-No. 1060 Manual on WIS.

2. Audits and certification

a) Auditors and certifiers shall be or shall become members of TT-CAC. New members:

i) must have relevant technical or audit experience (the nomination form is at http://wis.wmo.int/file=1117);

ii) must be a member (core or associate) of an OPAG-ISS expert team or have written commitment of the PR for the participation of the expert as a member of the TT-CAC,

Note that regional diversity of members of TT-CAC is necessary

b) GISC auditors should continue to be from a different region to the GISC

c) A GISC should be audited by two experts.

i) One of the two experts must have been involved in previous GISC audit

d) DCPCs require only one TT-CAC coordinator

i) New members will be mentored

ii) The coordinator will ask a GISC to undertake tests with the DCPC

iii) It is expected that the centre's principal GISC will undertake the tests

e) TT-CAC workspace and online databases are restricted to access only by TTCAC (and Secretariat)

3. GISC audits

a) In a similar way to an ISO 9001:2008 audit process, the audit will follow the principle of alternating full and intermediate audits aligned with CBS/EC cycle of four years.

b) CBS endorsement is based on continued successful audit outcomes

i) Validity, intermediate audit (interim four years)

(1) A mid-cycle review of performance and compliance to provide, if necessary, opportunities to introduce corrective actions well in advance of a full audit.
(2) Full audit (every second audit – i.e. every eight years)
(a) Will result in recommendation for affirmation or cancellation of endorsement

c) Recurring audit will check that WIS Centres have implemented any new requirements or agreed practices due, and corresponding tests will be identified and undertaken.

i) These changes to audit procedure will be included in the guidelines on centre audit and demonstration process.

d) Travel and per diem should be at the GISC's expense and arranged through WMO.

4. Public notification of type of CBS endorsement

a) Centre endorsements are published only as "CBS endorsed" with no public declaration of whether endorsement was with "qualifications".

b) Details of centres review audits are confidential

c) Auditors will have access to the centre's previous reports in order to perform their role.

5. Review of audits with qualification.

a) GISCs that have received an "endorsed with qualifications" have two years from the day of the audit to demonstrate that they have taken remedial action on the points of qualification.

b) TT-CAC will investigate GISCs that have received an "endorsed with qualifications" and have not demonstrated that they have taken remedial action on the points of qualification within 2 years from the day of audit. TT-CAC should report to CBS on the progress in addressing the aspects that incurred the "Qualification." TT-CAC can recommend to CBS that it revoke its endorsement.

6. Recurring audits.

a) GISCs should be audited at least once every four years.

b) Review cycle should start from date of "CBS endorsement", or for centres endorsed before 1 Jan 2012 (the date WIS became operational) the cycle will be based on 1 Jan 2012.

i) Audit timings will need to be coordinated with the availability of experts to undertake the audit, but should take place within the calendar year of the anniversary

ii) The CBS endorsement date should be recorded in the WIS centre database.

iii) The date the centre became operational should be recorded if known.

7. DCPCs reviews

a) The DCPC review cycle will be eight years.

b) Reviews will cover all aspects of WIS compliance.

8. NCs reviews

a) Review of NCs compliance is the responsibility of the Permanent Representative in liaison with the NC and its Principal GISC.

9. Ad hoc audits or reviews

a) An ad hoc audit or review can be requested by the president of CBS

i) For example due to non-conformance causing problems with WIS operations.

10. Full audits of GISCs

a) Shall include site visit using practices in line with those of the ISO 9000 series standards.

11. Audit process for GISCs

a) Scope of audits

i) "Full" audits will cover all aspects of WIS compliance

ii) "Interim" audits will focus on a particular subset of topics
(1) Actual elements to be focused on will be determined by ICT-ISS or its delegated expert team in coordination with ICT-ISS members
(2) Centres will be told in advance of which subset of topics
(3) Possible focus areas for reviews in interim audits include:
(a) GISC to GISC backup
(b) Security
(c) Monitoring
(d) Quality of service provided by the WIS
(e) WIS core network (e.g. in 2014 this was the RMDCN NG)
(i) connectivity and management
(ii) Cache "Globally distributed data" content
(f) Management of area of responsibility
(i) Capacity development
(ii) AMDCN (connects GISC to NCs and DCPCs in its area)
1. Cache "Area of responsibility" content
(iii) Participation in WIS coordination and planning mechanisms (e.g. CBS IPETs, ETs and TTs)

12. Audit or review outcome

a) Format of report

i) TT-CAC will use a template for final reports, although the content will reflect the topics audited.

b) Will be categorized into Endorsed, Endorsed with Qualification or Not Endorsed

c) Audit or review recommendation will be provided to the President of CBS and to the Director of WIS

Annex 3 to Recommendation 21 (CBS-Ext.(2014))

WMO INFORMATION SYSTEM – USE CASES

1. Insert the following Appendix B of the *Guide to the WMO Information System* (WMO-No. 1061) containing Use Cases for WIS Technical Specifications

APPENDIX B. WIS Technical Specifications – Use cases.

General

1. This appendix provides the Use Cases for major WIS Functions relating to the WIS Technical Specifications as described in Part IV of WMO-No. 1060 Manual on the WMO Information System. Use cases are designed to help system developers understand how the system is supposed to operate given certain pre conditions, and reactions to decisions during processing.

2. The content of most of the Use Cases given in this Appendix follows closely the work of the SIMDAT project led by the European Centre for Medium-Range Weather Forecasting (ECMWF). The form of the Use Cases follows the general guidance of Unified Modelling Language [UML]. It also uses a specific template derived from an example published by Karl E. Wiegers (with permission granted to use, modify, and distribute the template).

3. The following table provides a key to the elements of the Use Case template as used herein.

Use Case Goal – Brief description of the reason for and outcome of this Use Case, or a high-level description of the sequence of actions and the outcome of executing the Use Case.
Actors – An actor is a person or other entity, external to the system being specified, who interacts with the system (includes the actor that will be initiating this Use Case and any other actors who will participate in completing the Use Case). Different actors often correspond to different user classes, or roles, identified from the customer community that will use the product.
Trigger – Event that initiates the Use Case (an external business event, a system event, or the first step in the normal flow.
Pre-conditions – Activities that must take place, or any conditions that must be true, before the Use Case can be started.
Post-conditions – The state of the system at the conclusion of the Use Case execution.
Normal Flow – Detailed description of the user actions and system responses that will take place during execution of the Use Case under normal, expected conditions. This dialog sequence will ultimately lead to accomplishing the goal stated in the Use Case name and description.
Alternative Flows – Other, legitimate usage scenarios that can take place within this Use Case.
Exceptions – Anticipated error conditions that could occur during execution of the Use Case, and how the system is to respond to those conditions, or the Use Case execution fails for some reason.
Includes – Other Use Cases that are included ("called") by this Use Case (common functionality appearing in multiple Use Cases can be described in a separate Use Case included by the ones that need that common functionality).
Notes and Issues – Additional comments about this Use Case and any remaining open issues that must be resolved. (It is useful to Identify who will resolve each such issue and by what date.)

Table B1. Key to Elements in the Use Case Template

Note: The DAR Metadata Catalogue holds WIS Discovery Metadata records.

Use Case B.1, Provide Metadata for Data or Product

Use Case Goal	Metadata for any data or product file to be available from the DCPC or GISC is created or updated in the DAR Metadata Catalogue of the DCPC or GISC
Actors	Metadata Originator (NC or DCPC) Metadata Catalogue Publisher (DCPC or GISC)
Pre-Conditions	(1) The Metadata Originator is authorized to update the DAR Metadata Catalogue for the associated file(s) (2) The Metadata Originator has the necessary information and the ability to update the DAR Metadata Catalogue for the associated file(s) (3) The Metadata Catalogue Publisher supports facilities for authorized Metadata Originators to update the metadata for the associated file(s)
Post-Conditions	The DAR Metadata Catalogue has changes made by the Metadata Originator
Normal Flow	The authorized Metadata Originator uses a facility supported by the Metadata Catalogue Publisher to update the DAR Metadata Catalogue for the associated file. Typically, two kinds of

	maintenance facilities are supported. One is a file upload facility for "batch" updating (add, replace, or delete metadata records treated as separate files). The other is an online form for changing metadata records treated as entries in the DAR Metadata Catalogue (add, change, or delete of elements in a record as well as whole records). The Metadata Catalogue Publisher maintains the updated DAR Metadata Catalogue as a searchable resource offered to all authorized searchers (see Use Case B.6). The Metadata Catalogue Publisher also shares the metadata as a part of the logically centralized but physically distributed catalogue across WIS centres.
Notes and Issues	This set of actions is a simple extrapolation from existing GTS practice, adding the particular standard format for WIS metadata.
Last Updated	30 Jun 2014
Last Updated By	WMO Secretariat

Use Case B.2, Upload Data or Product to DCPC or GISC

Use Case Goal	Data or product is sent as a file to a DCPC or GISC
Actors	Data Sender (NC or DCPC) Data Receiver (DCPC or GISC)
Pre-Conditions	(1) Appropriate metadata to be associated with the file is already available in the DAR Metadata Catalogue of the DCPC or GISC (if not, see Use Case B.3) (2) The Data Sender is authorized to send the file to the Data Receiver (3) The Data Receiver supports a method for uploading the file, which the Data Sender is able to use
Post-Conditions	The data or product uploaded by the Data Sender is received and stored by the Data Receiver.
Normal Flow	The Data Sender uses his authorized access to send the file using an appropriate transmission method supported by the Data Receiver. Typically, the transmission is accomplished using GTS or a file transfer method available over the Internet. A file naming convention or other agreed mechanism is used to make an association between the file and its metadata
Notes and Issues	This set of actions builds on existing GTS practice, supplemented with other file transfer mechanisms such as the Internet.
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Last Updated By	WMO Secretariat

Use Case B.3, Control Metadata Association to Data or Product

Use Case Goal	Confirm that metadata for a data or product file at the DCPC or GISC already exists in the DAR Metadata Catalogue before the data or product is available
Actors	Data Sender (NC or DCPC) Data Receiver (DCPC or GISC)
Pre-Conditions	(1) Data or product has been sent as a file from a Data Sender (Use Case B.1) (2) DAR Metadata Catalogue is current with all updates (Use Case B.2)
Post-Conditions	An error is communicated when there is not confirmation that a given file is associated appropriately with metadata in the DAR Metadata Catalogue
Normal Flow	On receipt of a file containing a data or product, the Data Receiver checks the current DAR Metadata Catalogue to confirm that the file has an associated metadata record. If such a record is not found within two minutes after receipt of the file, an error message is sent to the Data Sender.
Notes and Issues	This control action addresses the condition wherein data arrives before its associated metadata. Rather than rejecting the file immediately, a grace period of two minutes is allowed before the data file is regarded as erroneous.
Last Updated	30 Jun 2014
Last Updated By	WMO Secretariat

Use Case B.4, Manage Cache of Data across GISCs

Use Case Goal	GISCs manage a logically centralized collection containing at least a 24 hour cache of data and

	products agreed by WMO for routine global exchange
Actors	Data Administrators at each of the GISCs
Pre-Conditions	(1) At each GISC, the cache of data and products received from NCs and DCPCs in its area of responsibility is current (2) Transmission and control mechanisms across GISCs are available (3) All Data Administrators are authenticated and authorized as needed
Post-Conditions	The cache of data and products is accessible as a logically centralized collection that includes current data and products at each GISC
Normal Flow	A Data Administrator monitors the transmission methods and control mechanisms that enable a logically centralised view of the physically distributed cache of data and products. Depending on the methods in place, a Data Administrator takes various corrective actions whenever the cache is not available as required.
Notes and Issues	At this point in WIS system design, it has not been decided how the GISCs will accomplish centralization of the cache.
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Last Updated By	WMO Secretariat

Use Case B.5, Maintain Identification and Role Information for WIS Users

Use Case Goal	Internal and external users of WIS are able to be identified as needed for their authentication, and their role information is maintained as needed for their authorizations to perform specific functions
Actors	Users of WIS (internal and external) Administrators of authentication and authorization at WIS Centres
Pre-Conditions	(1) Administrators have agreed authentication policies delineating the credentials required to establish identity of a WIS user (2) Administrators have agreed authorization policies delineating which roles are authorized to perform each WIS action (3) Administrators have mechanisms to create and maintain identification information needed for authentication of users of WIS (4) Administrators have mechanisms to create and maintain role information needed for authorization of authenticated users of WIS
Post-Conditions	WIS Centres collectively have the ability to authenticate each user of WIS and authorize him to perform all of the functions appropriate to his role, and only those functions appropriate to his role
Normal Flow	Identification and role information about candidate or current users of WIS are to be recorded through facilities controlled by WIS Centres. Typically, two kinds of facilities should be supported. One is a file upload facility for "batch" updating (add, replace, or delete the identification and role records as separate files). The other is an online form for changing identification and role records (add, change, or delete elements in a record as well as whole records). Administrators of authentication and authorization at WIS Centres share the updated identification and role information as a resource available as needed across WIS Centres.
Notes and Issues	At this point in WIS system design, mechanisms have not been decided for handling identification and role information as needed across WIS centres.
Last Updated	30 Jun 2014
Last Updated By	WMO Secretariat

Use Case B.6, Discover Data or Products

Use Case Goal	A user of WIS finds available WMO data or products that he wants to receive.
Actors	Data Searcher
Pre-Conditions	(1) The DAR Metadata Catalogue is accessible for browsing or searching (2) The GISC infrastructure provides a unified catalogue view to the user (i.e., the catalogue is logically centralized although physically distributed)
Post-Conditions	The Data Searcher has information needed to select relevant data or products.

Normal Flow	The Data Searcher discovers available WMO data and products by browsing the DAR Metadata Catalogue or by searching the DAR Metadata Catalogue using discovery concepts such as subject keywords, geographic extent, and temporal range. As a result of his browsing or searching, the Data Searcher gets a relevance-ordered list of data and products including "data or product metadata" such as data origin, data type, generation date, availability, and use constraints, among other characteristics.
Notes and Issues	At this point in WIS system design, multiple methods can be envisioned for logically centralizing the physically distributed DAR Metadata Catalogue.
Last Updated	30 Jun 2014
Last Updated By	WMO Secretariat

Use Case B.7, Ad Hoc Request for Data or Product ("Pull")

Use Case Goal	A user of WIS requests WMO data or product on an ad hoc basis
Actors	User of WIS WIS Centre
Pre-Conditions	(1) The desired data or product has been identified by the user of WIS (2) The user of WIS has been authenticated and authorized to retrieve the desired data or product from the WIS centre (3) Delivery is achievable through one of the supported mechanisms for the transmission of the desired data or product, and within the published service level commitment of the WIS centre
Post-Conditions	Data or product is readied for delivery to the user of WIS according to the service level commitment of the WIS centre
Normal Flow	Once the user has identified the desired data or product, he requests delivery on a one-time basis. (Use Case B.8 covers the alternate choice, recurring delivery.) The WIS Centre authenticates the user and checks authorization for delivery of the product according to the user's role. The WIS centre then sets up delivery through any of a broad range of online and offline options (delivery options are described in Use Case B.9).
Last Updated	30 Jun 2014
Last Updated By	WMO Secretariat

Use Case B.8, Subscribe to Data or Product ("Push")

Use Case Goal	A user of WIS can subscribe to receive data or products on a recurring basis
Actors	User of WIS WIS Centre
Pre-Conditions	(1) The desired data or product has been identified by the user of WIS (2) The user of WIS has been authenticated and authorized to retrieve the desired data or product from the WIS centre (3) Delivery is achievable through one of the supported mechanisms for the transmission of the desired data or product, and within the published service level commitment of the WIS centre
Post-Conditions	Data or product is readied for delivery to the user of WIS according to the service level commitment of the WIS centre
Normal Flow	Once the user has identified the desired data or product, he requests to subscribe to receive the data or products on a recurring basis. (Use Case B.7 covers the alternate choice, one-time delivery.) The WIS Centre authenticates the user, checks authorization for delivery of the product according to the user's role. The WIS centre then sets up delivery through any of a broad range of online and offline options (described in Use Case B.9). As necessary, the WIS Centre updates the Dissemination Metadata associated with the subscription (Use Case B.10).
Last Updated	30 Jun 2014
Last Updated By	WMO Secretariat

Use Case B.9, Download Data or Product from WIS Centre

Use Case Goal	A user of WIS receives from a WIS Centre, on an ad hoc or subscription basis, data or products transmitted as files

Actors	User of WIS WIS Centre
Pre-Conditions	(1) Data or product is ready for delivery to the authenticated and authorized user, as requested through one of the supported transmission mechanisms and according to the service level commitment of the WIS centre (2) For subscription delivery, the WIS Centre has access to subscription information in the Dissemination Metadata Catalogue (see Use Case B.10)
Post-Conditions	Selected data or products are received by the user of WIS
Normal Flow	The WIS Centre sends files containing the requested data or products, using an appropriate transmission method as indicated in the associated subscription information accessible through the Dissemination Metadata Catalogue. Typically, the transmission is accomplished using GTS or a file transfer method available over the Internet, such as HTTP, OpenDap, FTP, SFTP, GFTP, email, etc). In any case, transmission must be efficient and reliable (checksum and error recovery mechanisms are required at minimum).
Last Updated	30 Jun 2014
Last Updated By	WMO Secretariat

Use Case B.10, Provide Dissemination Metadata

Use Case Goal	Metadata concerning delivery specifics of subscription(s) to data and products from a DCPC or GISC are created or updated in the Dissemination Metadata Catalogue
Actors	Subscription Registrar (NC or DCPC) Dissemination Catalogue Publisher (DCPC or GISC)
Pre-Conditions	(1) The Subscription Registrar is authorized to update the Dissemination Metadata Catalogue for the given subscription(s) (2) The Subscription Registrar has the necessary information and the ability to update the Dissemination Metadata Catalogue for the given subscription(s) (3) The Dissemination Catalogue Publisher supports facilities for authorized Subscription Registrars to update the metadata for the given subscription(s)
Post-Conditions	The Dissemination Metadata Catalogue has changes made by the Subscription Registrar
Normal Flow	The authorized Subscription Registrar uses a facility supported by the Dissemination Metadata Catalogue Publisher to update the Dissemination Metadata Catalogue for the given subscription(s). Typically, two kinds of maintenance facilities are supported. One is a file upload facility for "batch" updating (add, replace, or delete metadata records treated as separate files). The other is an online form for changing metadata records treated as entries in the Dissemination Metadata Catalogue (add, change, or delete of elements in a record as well as whole records). The Dissemination Metadata Catalogue Publisher maintains the updated Dissemination Metadata Catalogue as a reference resource accessible as part of a logically centralized but physically distributed catalogue across WIS centres.
Notes and Issues	At this point in WIS system design, it is has yet to be defined how each Dissemination Metadata Catalogue Publisher will communicate changes to each physically distributed part of the logically centralized Dissemination Metadata Catalogue.
Last Updated	30 Jun 2014
Last Updated By	WMO Secretariat

Use Case B.11, Report Quality of Service across WIS Centres

Use Case Goal	Managers of WIS Centres receive performance reports of operations against agreed quality of service indicators
Actors	WIS Centre Managers
Pre-Conditions	(1) Measurable quality of service indicators are agreed (2) Schedule of reporting and specifics of reporting formats are agreed
Post-Conditions	WIS Centre managers have performance information needed to manage WIS operations across the range of GISC, DCPC and NC services
Normal Flow	On a schedule as mutually agreed, all WIS Centre managers send performance reports of operations against agreed quality of service indicators.
Notes and Issues	It can be anticipated that WIS will eventually have agreements that address quality of service

	requirements. These should include data and network security as well as performance and reliability. CBS is investigating monitoring processes, including reviewing established processes for the World Weather Watch. The current status can be monitored under http://wis.wmo.int/folder=63
Last Updated	30 Jun 2014
Last Updated By	WMO Secretariat

Annex 4 to Recommendation 21 (CBS-Ext.(2014))

WMO INFORMATION SYSTEM – DEMONSTRATION TEST CASES

1. Insert the following Appendix C of WMO-No. 1061 – *Guide to the WMO Information System* containing WIS Demonstration Test Cases

APPENDIX C. WIS Demonstration Test Cases.

General

1. This appendix provides the test cases for major WIS Functions relating to the WIS technical specifications (TechSpecs) as describe in Part IV of the Manual on the WMO Information System. WIS demonstration test cases differ from Use Cases in that they test a process behaves correctly by looking at the particular input and test to see if the result is as expected.

2. The guidelines for DCPCs and GISCs on how to demonstrate their compliance to CBS are online at http://www-db.wmo.int/WIS/centres/guidance.doc.

3. Guidance for NCs on how to work with their Principal GISC to demonstrate their compliance is included in Regional WIS Implementation Plans available at: http://wis.wmo.int/folder=75.

4. In order to be WIS compliant, all centres should be able to complete those demonstration test cases that are applicable to the services a centre is running. Demonstration test cases are based on the WIS Technical Specifications and Use Cases defined in WMO-No. 1060 – *Manual on the WMO Information System* and in Appendix B of this Guide to WIS respectively.

5. There are six Test Cases for GISCs, labelled WIS-TC1 to WIS-TC6. All, except for WIS-TC4 are also relevant to DCPCs where they are applicable. The six Test Cases are list under Part 1 of this Appendix.

6. There are three test cases for NCs, labelled as NC-TC1, NC-TC2 and NC-TC3.

Part 1 – WIS Demonstration Test Cases for GISCs and DCPCs

Test Case Name: WIS Demonstration Test Case 1	
Uploading of Metadata for Data and Products into DAR catalogue	
Test Case ID	WIS-TC1
Component	Metadata Management

Purpose of test

Validate the function of adding, updating and deleting metadata records from other WIS centres.

All metadata records must be checked against the relevant schemas. (e.g. The record should be rejected if not fitting the schema)

Note 1: The term "upload" refers to the movement of metadata records between the WIS centre that provides the metadata and the WIS centre that manages the DAR catalogue. It can actually be implemented as a "pull" initiated from the DAR catalogue site, or as a "push" initiated by the metadata provider.

Note 2: this functionalities can be implemented as:
- A web interface allowing registered users to manage their metadata interactively
- A machine-to-machine interface allowing automated batch processing of metadata.

It is necessary that GISCs implement both methods.

Relevant technical specifications

- Tech specs 1 (Uploading of metadata)
- Tech specs 8 (DAR Catalogue Search and Retrieval)

Precondition

1. Have network connection (dedicated and/or public connection) with other WIS centre(s)
2. Have a file upload facility for collecting metadata from other WIS centre(s)
3. Have a fully functional DAR catalogue
4. Have a registered user/process that is authorized to manage metadata of a given WIS centre
5. Have a web interface to the DAR catalogue that allow searches (see TC6)

Test Steps

	Description	Expected Results	Actual Results
1	A user/process adds a valid metadata record to the DAR catalogue	The metadata record must be found when browsing/searching the DAR catalogue	
2	A user/process modifies a record from the DAR catalogue,	The modification should be immediately visible when browsing/searching the DAR catalogue	
3	A user/process deletes a record from the DAR catalogue,	The deleted record should not be found when browsing/searching the DAR catalogue	
…	A authorized user/process attempts to upload an invalid metadata record	The user/process must be notified of the fact that the metadata record is invalid. The addition/update operation is aborted. The DAR catalogue is unchanged.	

…	A authorized user/process attempts to upload a record with a unique identifier that is already in the DAR catalogue	The DAR catalogue should not contain record with duplicate identifiers. Either: 1. The new metadata record replaces the old metadata record. The old metadata record should not be present in the catalogue. The new metadata record must be found when browsing/searching the catalogue 2. The user/process must be notified of the fact that the record is a duplicate. The addition/update operation is aborted. The DAR catalogue is unchanged. Note: it is essential to ensure an update is an edit and not an accidental duplication	
…	Access control - No unauthorized addition 1	A non-authorized user/process should not be able to add a metadata record to the DAR catalogue	
…	Access control - No unauthorized addition 2	A user/process should not be able to add a metadata record to the DAR catalogue representing data from another WIS centre	
…	Access control - No unauthorized modification 1	A non-authorized user/process should not be able to modify a metadata record from the DAR catalogue	
…	Access control - No unauthorized modification 2	A user/process should not be able to modify a metadata record from the DAR catalogue that belongs to another WIS centre	
…	Access control - No unauthorized deletion 1	A non-authorized user/process should not be able to delete a metadata record to the DAR catalogue	
…	Access control - No unauthorized deletion 2	A user/process should not be able to delete a metadata record from the DAR catalogue that belongs to another WIS centre	

Centre		Organization		Country	
Test Date					

Test Case Name: WIS Demonstration Test Case 2	
Synchronizing DAR catalogues between GISC nodes	
Test Case ID	WIS-TC2
Component	Metadata management
Purpose of test	
GISC should have a global view of metadata. Validate the synchronization of the DAR metadata catalogue between GISCs node via a synchronization protocol GISC to GISC synchronization (between separate centres) – Timeliness of synchronization, accuracy Test should complement the "add, change and delete mechanisms for metadata demonstrated in test 1.	
Requirements Covered	
• Tech specs 1 (Uploading of metadata) • Tech specs 8 (DAR Catalogue Search and Retrieval) • Tech specs 9 (Consolidated View of Distributed DAR Metadata Catalogues)	
Precondition	
1. Have network connection (dedicated and/or public connection) with other GISC(s). 2. Have DAR catalogue already populated at each GISC participating to the test 3. Have a synchronization facility for synchronizing metadata with other GISC(s)	
Test Steps	

	Description	Expected Results	Actual Results
1	Synchronize the DAR metadata catalogue	Identical content of the DAR metadata catalogue of the GISC(s) participating to the test: • Number of records should be identical • The list of unique identifier should identical • A random selection of records should be identical	
2	Add new metadata record at GISC 1	The uploaded metadata record is added into the DAR Metadata Catalogue of the other GISC(s) participating to the test.	
3	update metadata record at GISC 1	The updated metadata record is added into the DAR Metadata Catalogue of the other GISC(s) participating to the test.	
4	Delete metadata file record belonging to GISC1 at GISC 1	The concerned metadata recorder is deleted in the DAR Metadata Catalogue of the other GISC(s) participating to the test.	
5	Delete metadata file record that doesn't belong to GISC1 at GISC 1	The concerned metadata recorder is uploaded in the DAR Metadata Catalogue of GISC1 from DAR Metadata Catalogue of the other GISC(s) participating to the test.	
…	Re-play 2-5 from GISC2 …		

Centre		Organization		Country	
Test Date					

Test Case Name: WIS Demonstration Test Case 3	
Uploading and downloading of data between WIS centres	
Test Case ID	WIS-TC3
Component	
Purpose of test	
Validate the upload and download of data and products and association with metadata	
Requirements Covered	
• Tech specs 2 (Uploading of data and products) • Tech specs 10 (Downloading file via dedicated network) • Tech specs 11 (Downloading file via non-dedicated network) • Tech specs 12 (Downloading file via other methods)	
Precondition	
1. Have network connection (dedicated and/or public connection) with other WIS centre 2. Have file upload and download facilities (FTP, mail, HTTP, …) 3. Have data available for upload or download 4. Have DAR facilities available at GISC.	
Test Steps	

	Description	Expected Results	Actual Results
1	a. upload a file which is associated with a metadata record in the DAR catalogue of the GISC to a GISC centre b. use DAR facilities to search the metadata then retrieve the file	a. The uploaded file has been delivered to the GISC and match with the corresponding metadata b. The file can be downloaded	
2	GISC Only a. Upload a file which is not associated with a metadata record in the DAR catalogue of the GISC to a GISC centre b. later upload the metadata record associated to the file to a GISC centre. c. use DAR facilities to search the metadata en retrieve the file	a. The uploaded file has been delivered to the GISC b. the DAR catalogue is updated with new record. Previously received file is associated with the metadata c. The file can be downloaded	
3			
4			
…			

Centre		Organization		Country	
Test Date					

Test Case Name: WIS Demonstration Test Case 4	
Centralization of Globally Distributed Data (Applies only to GISCs)	
Test Case ID	WIS-TC4
Component	24 hours cache at GISC

Purpose of test

Validate the completeness of the 24h cache

- Finding a current data or product originating from another centre via the GISC DAR search mechanism, and retrieve that item from the GISC cache.

An attached document describing the process how the GISC will ensure it holds a complete cache for 24 hours, including performance metrics

Requirements Covered

- Tech specs 3 (Centralization of Globally Distributed Data)
- Tech specs 8 (DAR …)

Precondition

1. Have network connection (dedicated and/or public connection)
2. Have DAR catalogue already populated with metadata of the 24h data for global exchange
3. Have DAR facilities available through a portal
4. Have a cache with at least the last 24 h data for global exchange

Test Steps

	Description	Expected Results	Actual Results
1	Search in catalogue for data/products from other centre and other program in other area and retrieve selected data or products	The selected data/products can be retrieved from GISC	
2	Search in catalogue for data/products 6h old and retrieve selected data or products	The selected data/products can be retrieved from GISC	
3	Search in catalogue for data/products12h old and retrieve selected data or products	The selected data/products can be retrieved from GISC	
4	Search in catalogue for data/products 18h old and retrieve selected data or products	The selected data/products can be retrieved from GISC	
5	Search in catalogue for data/products 24h old and retrieve selected data or products	The selected data/products can be retrieved from GISC	

Centre		Organization		Country	
Test Date					

Test Case Name: WIS Demonstration Test Case 5	
Maintenance of users, roles, authorization and authentication	
Test Case ID	WIS-TC5
Component	Management of users and access
Purpose of test	
Create and exercise a variety of user types	
Relevant Technical Specifications	
• Tech specs 4 (Maintenance of User Identification and Role Information) • Tech specs 6 (Authentication of a User) • Tech specs 7 (Authorization of a User Role) • Tech specs 13 (Maintenance of Dissemination Metadata)	
Precondition	
1. The Centre has authority to provide access to user (i.e. PR approval from users country) 2. The user interface is via the internet (i.e. web page)	
Test Steps	

	Description	Expected Results	Actual Results
1	Provide access for an external user to search metadata	Temporary user can search metadata, but not access data from the GISC or cache, or subscribe to data.	
	a) User goes to search web page b) User makes metadata search c) Tries to access data	a) User has access to search page b) User finds metadata c) User tries to access data and is referred to authorization page at data source. Cannot access data without validating in an authorized user role	
2	Create accounts with access to WIS metadata and data for a WMO centre authorized user	Two users are created. One with access to metadata only, the other with the ability to access the Centre subscription service or ad hoc request from the cache	
	a) User goes to registered user web page b) User is required to login or create account c) User registers account and selects role of valid WMO member with authority to access WIS data (eg is from WMO NC) d) User enters login details e) User makes metadata search f) Tries to access WMO globally available data from the centre	a) User has access to login page b) New user, so has to create an account c) User account is validated as a WMO NC member and account is created. The user receives a user login (eg code via email or encrypted symbol) d) User is logged in. As user us validated as WMO NC member, he is allocated access to search and access to download data from cache and to subscription services e) User finds metadata	

	g) User tries to access additional data at centre that he is not authorized to access h) Tries to access data or product at another site i) User subscribes to data for future delivery from centre j) User returns on another session and reuses login to search or subscribe k) User edits subscription details l) User cancels a subscription m) User logs out or leaves centre's site and tries to return to a bookmarked page at a later date and access data	f) User successfully accesses data from centre g) User receives advice that he is not authorized to access this data and referred to access page where he can request change in user role or re-login as another user h) User is referred to authorization page at other site. i) User receives scheduled data via agreed method at agreed time j) User maintains successful access with same access rights k) Users subscription details are updated and reflected in subsequent deliveries l) Users subscription details are updated and receives no further deliveries m) Attempting to use a bookmarked page from earlier session to access data, directs the user to the registered user login page.	
4	User checks status of account and subscriptions	User can view his account and subscription details, including historic and future transactions, and the status of current transactions	
…			

Centre		Organization		Country	
Test Date					

Test Case Name: WIS Demonstration Test Case 6	
DAR Catalogue Search and Retrieval	
Test Case ID	WIS-TC6
Component	DAR Catalogue

Purpose of test

The purpose of the test case is to assess the functionality of the DAR catalogue.

Relevant technical specifications

Tech specs 8 (DAR Catalogue Search and Retrieval)

Precondition

1. The DAR catalogue is loaded with representative number of WMO Core metadata records that represent a variety of data and products, in particular, the records should represent several time ranges (climate and real-time), several geographical extents (from point to global coverage) and records from several discipline (meteorology, hydrology,…) , when applicable for the function of the candidate centre (e.g. GISC, DCPC, …)
2. A web based user interface is made available on the open Internet to provide access to the DAR catalogue
3. There exists a registered user that is allow to retrieve some data and/or product
4. The number of records returned may be subject to size limits of system e.g. 1000 record limit

Test Steps

	Description	Expected Results	Actual Results
1	Browsing	Any record in the DAR must be reachable by browsing the catalogue	
2	Free text search - The user input one or more words in a web form and submit the request	All records that contain the required words. If the user is allowed to select a Boolean operation between the results (i.e. and/or, …), the result should fulfil this operation.	
3	Geographic search - The user input a rectangular geographical area (using a form of a map).	All records that are contained in the area or that overlap with the area, depending on the implementation (the user should be aware of the matching algorithm used). The system should handle the poles and the date line properly.	
…	Time search - The user input either a time interval or a point in time in a web form	All records that represent a time interval or point in time that are contained in or overlap with the requested interval or point in time, depending on the implementation (the user should be aware of the matching algorithm used).	
…	Combination of the above - A user can select a combination of any two or all of the above simultaneously.	All records that matches all the selected criteria.	
	Invalid search made	User receives a meaningful message informing of error	
	ISO23950 Search by URL (SRU)	The above tests will test successfully via SRU interface.	
…	Visualization of a metadata	The user should be able to select a metadata record when browsing or from a search result list. The record must be render in a human readable form.	
	Selection and retrieval of data	The user should be able to select data and/product products either when browsing or from a search result list or when visualizing a meta record. The user is presented with a mean to select instances that are associated with the chosen record. The system must provide a retrieval/referral mechanism that will allow the user to receive the data noting the data may be available from another site.	
…			

Centre		Organization		Country	
Test Date					

Part 2 – WIS Demonstration Test Cases for NCs

Test Case Name: NC Demonstration Test Case 1	
Uploading of Discovery Metadata for Data and Products into DAR catalogue	
Test Case ID	NC-TC1
Component	Metadata Management

Purpose of test

Validate the function of adding, updating and deleting metadata records from NC to the Principal GISC.

All metadata records must be checked against the relevant schemas. (e.g. The record should be rejected if not fitting the schema)

Note 1: The term "upload" refers to the movement of metadata records between the National Centre that provides the metadata and the WIS centre that manages the DAR catalogue hosted by the Principal GISC. It can actually be implemented as a "pull" initiated from the DAR catalogue site, or as a "push" initiated by the metadata provider.

Note 2: this functionalities can be implemented as:
- A web interface allowing registered users to manage their metadata interactively
- A machine-to-machine interface allowing automated batch processing of metadata.

All GISCs support both methods. The NC may choose one or both methods

Relevant technical specifications

- Tech specs 1 (Uploading of metadata)
- Tech specs 8 (DAR Catalogue Search and Retrieval)

Precondition

1. Network connection (dedicated and/or public connection) exists between the NC and GISC
2. GISC has a file upload facility for collecting metadata from other WIS centre(s)
3. GISC has a fully functional DAR catalogue
4. GISC has a registered user/process that is authorized to manage metadata of a given WIS centre
5. GISC has a web interface to the DAR catalogue that allow searches (see WIS-TC6[1)]

Test Steps

	Description	Expected Results	Actual Results
1	A user/process adds a valid metadata record to the DAR catalogue	The metadata record must be found when browsing/searching the DAR catalogue	
2	A user/process modifies a record from the DAR catalogue,	The modification should be immediately visible when browsing/searching the DAR catalogue	
3	A user/process deletes a record from the DAR catalogue,	The deleted record should not be found when browsing/searching the DAR catalogue	

1 WIS Demonstration Process – http://www-db.wmo.int/WIS/centres/guidance.doc

…	A authorized user/process attempts to upload an invalid metadata record	The user/process must be notified of the fact that the metadata record is invalid. The addition/update operation is aborted. The DAR catalogue is unchanged.	
…	A authorized user/process attempts to upload a record with a unique identifier that is already in the DAR catalogue	The DAR catalogue should not contain record with duplicate identifiers. Either: 1. The new metadata record replaces the old metadata record. The old metadata record should not be present in the catalogue. The new metadata record must be found when browsing/searching the catalogue 2. The user/process must be notified of the fact that the record is a duplicate. The addition/update operation is aborted. The DAR catalogue is unchanged. Note: it is essential to ensure an update is an edit and not an accidental duplication	
…	Access control No unauthorized addition 1	A non-authorized user/process should not be able to add a metadata record to the DAR catalogue	
…	Access control – No unauthorized addition 2	A user/process should not be able to add a metadata record to the DAR catalogue representing data from another WIS centre	
…	Access control No unauthorized modification 1	A non-authorized user/process should not be able to modify a metadata record from the DAR catalogue	
…	Access control No unauthorized modification 2	A user/process should not be able to modify a metadata record from the DAR catalogue that belongs to another WIS centre	
…	Access control No unauthorized deletion 1	A non-authorized user/process should not be able to delete a metadata record to the DAR catalogue	
…	Access control No unauthorized deletion 2	A user/process should not be able to delete a metadata record from the DAR catalogue that belongs to another WIS centre	

Centre		Organization		Country	
Test Date					

Test Case Name: NC Demonstration Test Case 2					
Uploading and downloading of data between WIS centres					
Test Case ID	NC-TC2				
Component					
Purpose of test					
Validate the upload and download of data and products and association with metadata					
Requirements Covered					
• Tech specs 2 (Uploading of data and products) • Tech specs 10 (Downloading file via dedicated network) • Tech specs 11 (Downloading file via non-dedicated network) • Tech specs 12 (Downloading file via other methods)					
Precondition					
1. Network connection (dedicated and/or public connection) between the NC and GISC (includes via RTH where relevant 2. Have file upload and download facilities (FTP, mail, HTTP, …) 3. Have data available for upload or download 4. Have DAR facilities available at GISC.					
Test Steps					

	Description	Expected Results	Actual Results
1	a. upload a file which is associated with a metadata record in the DAR catalogue of the GISC to a GISC centre b. use DAR facilities to search the metadata then retrieve the file	a. The uploaded file has been delivered to the GISC and match with the corresponding metadata b. The file can be downloaded	

Centre		Organization		Country	
Test Date					

Test Case Name: NC Demonstration Test Case 3	
Maintenance of users, roles, authorization and authentication	
Test Case ID	NC-TC3
Component	Management of users and access
Purpose of test	
Create and exercise a variety of user types. Note: A centre may use the GISC user control interface	
Relevant Technical Specifications	
• Tech specs 4 (Maintenance of User Identification and Role Information) • Tech specs 6 (Authentication of a User) • Tech specs 7 (Authorization of a User Role) • Tech specs 13 (Maintenance of Dissemination Metadata)	
Precondition	
1. The Centre has authority to provide access to users (i.e. PR approval) 2. A process is in place between the NC and GISC for the Centre to authorize its users to use the GISC with appropriate access levels. 3. The user interface is via the internet (i.e. web page)	
Test Steps	

	Expected Results	Actual Results
cess for an external user to search	Temporary user can search metadata, but not access data from the GISC or cache, or subscribe to data.	
es to search web page kes metadata search access data	a) User has access to search page b) User finds metadata c) User tries to access data and is referred to authorisation page at data source. Cannot access data without validating in an authorized user role	
ounts with access to WIS metadata and VMO centre authorized user	Two users are created. One with access to metadata only, the other with the ability to access the Centre subscription service or ad hoc request from the cache	
es to registered user web page equired to login or create account isters account and selects role of valid ember with authority to access WIS data m WMO NC) ers login details kes metadata search	a) User has access to login page b) New user, so has to create an account c) User account is validated as a WMO NC member and account is created. The user receives a user login (eg code via email or encrypted symbol) d) User is logged in. As user us validated as WMO NC member, he is allocated access to search and access to download data from cache and to subscription services	

	f) Tries to access WMO globally available data from the centre g) User tries to access additional data at centre that he is not authorized to access h) Tries to access data or product at another site i) User subscribes to data for future delivery from centre j) User returns on another session and reuses login to search or subscribe k) User edits subscription details l) User cancels a subscription m) User logs out or leaves centre's site and tries to return to a bookmarked page at a later date and access data	e) User finds metadata f) User successfully accesses data from centre g) User receives advice that he is not authorized to access this data and referred to access page where he can request change in user role or re-login as another user h) User is referred to authorisation page at other site. i) User receives scheduled data via agreed method at agreed time j) User maintains successful access with same access rights k) Users subscription details are updated and reflected in subsequent deliveries l) Users subscription details are updated and receives no further deliveries m) Attempting to use a bookmarked page from earlier session to access data, directs the user to the registered user login page.	
4	User checks status of account and subscriptions	User can view his account and subscription details, including historic and future transactions, and the status of current transactions	
…			

Centre		Organization		Country	
Test Date					

Annex 5 to Recommendation 21 (CBS-Ext.(2014))

WMO INFORMATION SYSTEM COMPETENCIES

The provision of World Meteorological Organization Information System (WIS) services within a National Meteorological and Hydrological Service (NMHS) or related services might be accomplished by a variety of skilled personnel, including project managers, engineers, technicians, and IT personnel. Personnel in third party organizations (e.g. universities, international and regional institutions and centres, and private sector companies) and other providers might also supply data, products and information for the WIS service(s).

This document sets out a competency framework for personnel involved in the provision of WIS services, but it is not necessary that each person has the full set of competencies. However, within specific application conditions (see below), which will be different for each organization, it is expected that any institution providing WIS services will have staff members somewhere within the organization who together demonstrate all the competencies at the institution's infrastructural capacity level. The Performance and Knowledge Requirements that support the competencies should be customized based on the particular context of an organization. However the general criteria and requirements provided here will apply in most circumstances.

APPLICATION CONDITIONS

A. The organizational context, priorities and stakeholder requirements

B. The way in which internal and external personnel are used to provide WIS services

C. The available resources and capabilities (financial, human, technological, and facilities), and organizational structures, policies and procedures

D. National and institutional legislation, rules and procedures

COMPETENCIES

Infrastructure

1 Manage the physical infrastructure

2 Manage the operational applications

Data

3 Manage the data flow

4 Manage the data discovery

External Interactions

5 Manage WIS centre-centre interactions

6 Manage external user interactions

Overall service

7 Manage the operational service

COMPETENCY 1: MANAGE THE PHYSICAL INFRASTRUCTURE

Competency description

Prepare, plan, design, procure, implement and operate the physical infrastructure, networks and applications required to support the WIS centre

Performance components

IT operations control

1. Maintain the system in optimal operational condition by setting and meeting service levels, including:
    - configuration
    - preventative and corrective maintenance and servicing
    - equipment replacement or upgrade
    - networking and processing capacity
    - systems monitoring and reporting on and corrective actions
2. Contingency planning, operations backup and operations restore

Facilities management

3. Manage physical site security
4. Manage physical site environmental control

Knowledge and skill requirements

- General ICT skills
- Operation, configuration and maintenance of equipment and applications
- Recognized IT service management frameworks
- Current technologies and emerging trends
- Service level agreements

COMPETENCY 2: MANAGE THE OPERATIONAL APPLICATIONS

Competency description

Prepare, plan, design, procure, implement and operate the applications required to support the WIS functions

Performance components

1. Meet service levels by maintaining applications in optimal operational condition, through:
    - configuration of applications
    - monitoring and responding to applications' behaviour
    - preventative and corrective maintenance
    - replacement or upgrade of applications
2. Contingency planning and application backup and application restore
3. Ensure data integrity and completeness in the event of system failure
4. Ensure system security

Knowledge and skill requirements

- General ICT skills
- Operation, configuration and maintenance of applications
- Recognized IT service management frameworks
- Current technologies and emerging trends
- WIS functions and requirements
- WIS security policies

COMPETENCY 3: MANAGE THE DATA FLOW

Competency description

Manage the collection, processing and distribution of data and products through scheduled and on-demand services

Performance components

1 Ensure collection and distribution of data and products as per data policy

2 Publish data and products

3 Subscribe to data and products

4 Encode, decode, validate and package data and products

5 Create, update and maintain data flow catalogues

6 Manage connectivity between centres

7 Control the data flow to meet service levels

Knowledge and skill requirements

- System and network monitoring and viewing tools
- Data formats and protocols
- Licensing and data policies
- Message and file switching systems

COMPETENCY 4: MANAGE THE DATA DISCOVERY

Competency description

Create and maintain discovery metadata records describing services and information and upload to the WIS DAR catalogue

Performance components

1 Create and maintain discovery metadata records describing products and services

2 Add, replace or delete metadata records within the catalogue

3 Ensure that all information and service offerings from a WIS centre have complete, valid and meaningful discovery metadata records uploaded to the catalogue

Knowledge and skill requirements

- WMO and/or ISO docs e.g., complete and valid records
- Metadata entry and management tools
- Policies
- Discovery metadata concepts and formats
- Written English

COMPETENCY 5: MANAGE WIS CENTRE-CENTRE INTERACTIONS

Competency description

Manage relationships and compliance between your centre and other WIS centres

Performance components

1 Exchange information with other centres on operational matters

2 Facilitate registration of new WIS centres

3 Facilitate registration of new data and products by other WIS centres

4 Create and respond to WIS service messages, including GTS

Knowledge and skill requirements

- Knowledge of current exchanges and requirements for notification of operational changes
- Procedures and practices for registration of other centres and their data and products
- Service level agreements
- Written English

COMPETENCY 6: MANAGE EXTERNAL USER INTERACTIONS

Competency description

Ensure users, including data providers and subscribers, can publish and access data and products through WIS

Performance components

1 Register data providers and subscribers and maintain a service agreement

2 Set and register access criteria

3 Provide systems and support for users to publish and access data and products

4 Manage user relations to ensure a high satisfaction level

Knowledge and skill requirements

- Data policies
- External WIS interface
- WIS registration and monitoring tools and policies
- User support documentation and help files
- Written English

COMPETENCY 7: MANAGE THE OPERATIONAL SERVICE

Competency description

Ensure the quality and continuity of the service

Performance components

1 Coordinate all WIS functions and activities of the centre

2 Ensure and demonstrate compliance with regulations and policies

3 Monitor and meet quality and service performance standards

4 Ensure service continuity through risk management, planning and implementation of service contingency service backup and service restore, and ensure data continuity in the event of system failure

5 Plan and coordinate the delivery of new functionality

Knowledge and skill requirements

- General management skills
- Overview of local and external WIS operations and associated service agreements
- WIS regulations and policies
- Functional specification
- Written English

Annex 6 to Recommendation 21 (CBS-Ext.(2014))

WMO INFORMATION SYSTEM TRAINING AND LEARNING GUIDE

This guide is to assist trainers in the development and running of training courses for WIS personnel and to guide learners in what is expected of them. As this is a guide, it is not mandatory that you precisely follow its directions. You may find more appropriate ways for you to teach or learn something. However, it is essential that the learning outcomes are met.

This guide is not a syllabus. A syllabus is essentially a list of topics without indications of learning outcomes or how the learning is to be demonstrated. With a competency based approach, the focus is on learners acquiring and demonstrating the required competencies, rather than things that are “nice for them to know”.

This guide covers the whole gamut of competencies required for people working with WIS. It is important to note that these are the competencies required in a large WIS centre where they would normally be shared across a number of personnel. Although different WIS Centres may have the same competencies, the components and complexity and depth of each may vary. Further, an individual competency or component may not be required at a particular centre (if that work is not performed there) or by individuals within the centre.

Thus, the training should be tailored to each individual’s needs. These learning needs will depend on what is required to perform their work and what competencies and skills they already possess (recognition of prior competence). Training should be to fill these gaps, not to cover all of the possible content.

In a small centre, not all of the competencies are likely to be required. In any case, each individual working with WIS needs to be able to show that they are competent to perform those tasks which they are required to do. Where they already possess skills and are able to demonstrate competence against the assessment criteria (recognition of prior competence) they will be exempt from those sections of the training.

COMPETENCIES

Infrastructure

1 Manage the physical infrastructure

2 Manage the operational applications

Data

3 Manage the data flow

4 Manage the data discovery

External Interactions

5 Manage WIS centre-centre interactions

6 Manage external user interactions

Overall service

7 Manage the operational service

IN AND OUT OF SCOPE

Staff are expected to have standard professional skills and capabilities. The emphasis here is on WIS specific skills. Training in generic skills such as ICT systems and standard applications, networking, maintenance, database skills, project management, etc. would normally be outsourced or part of a person's training prior to working in the centre. The same applies to team-working and generic management skills.

ASSESSMENT

It is essential to ensure learning is transferred from the learning environment into operations. Assessment should thus simulate the operational conditions as closely as practicable. The emphasis is on what people are able to do, under the conditions in which they are required to do it, and with the tools they would normally use, rather than on what they know.

Examples of suitable assessment types include:

- Demonstrated performance
- Portfolio of examples of work they have done
- Recognition of prior competence
- Supervisor assessment certifying their competency – based on evidence of prior performance or working under supervision

As competency needs to be maintained on an ongoing basis continuing assessment may be required. This would normally be on a periodic basis at a frequency appropriate for the particular competency.

Competency based assessment means that staff are deemed capable of performing the job, not that they receive a pass mark of say 60%.

TYPES OF TRAINING

This document is not meant to be prescriptive in how training should be performed but offers some suggestions. Any mode of training is acceptable, as long as it is effective and the outcomes can be assessed against the competencies. It will depend on the competency to be assessed, the size of the WIS centre, available resources, and other factors.

Some forms of training that would be appropriate include:

- Working under supervision (on the job)
- Mentoring
- Self-directed study
- Internal or external courses (online or classroom), especially for generic skills
- Scenario based activities, including use cases
- Role plays, especially for external interactions

KEY LEARNING RESOURCES

- The key documents, along with their references, explaining the operation of WIS are:
- WMO-No. 1060 *Manual on the WMO Information System*
- WMO-No. 1061 *Guide to the WMO Information System*
- Use cases – for learning and for assessment – still need to reference these

UPDATES

As the training for WIS evolves it is expected that so, too, will this guide. Suggestions of ways to improve the document and ideas about how the training can be conducted are always welcome and should be sent to: wis-help@wmo.int

COMPETENCY 1: MANAGE THE PHYSICAL INFRASTRUCTURE

Prepare, plan, design, procure, implement and operate the physical infrastructure, networks and applications required to support the WIS centre.

Many of these skills are generic ITC skills and will have already been attained as part of prior education and training or will be provided by hardware and systems suppliers.

COMPETENCIES COMPONENTS

IT operations control

1 Maintain the system in optimal operational condition by setting and meeting service levels, including:

- configuration
- preventative and corrective maintenance and servicing
- equipment replacement or upgrade
- networking and processing capacity
- systems monitoring, reporting and corrective actions

2 Contingency planning, operations backup and operations restore

Facilities management

3 Manage physical site security

4 Manage physical site environmental control

Learning outcomes

You will be able to:

- Maintain the system in optimal operational condition
- Plan for upgrades, operations backups and operations restores
- Maintain site security and environmental control

You will learn:

- WIS specific systems
- WIS site security policies
- Service level agreements for your centre

Learning activities

To learn how to perform these job tasks you may:

- Attend training by systems and other outside providers
- Respond to typical monitoring reports
- Apply WIS site security measures and respond to typical incidents
- Apply WIS site environmental control measures and respond to typical incidents

Assessment

You must be able to:

- Configure and maintain system components
- Respond to monitoring reports
- Apply WIS site security measures and respond to typical incidents
- Apply WIS site environmental control measures and respond to typical incidents

Underpinning knowledge and skills

- General ICT skills
- Current technologies and emerging trends
- Recognized IT service management frameworks
- Service level agreements for your centre

Key learning resources

- Manufacturers' handbooks and guides
- Documentation of centre's facilities
- WIS/GTS manuals and guides
- Tools to monitor system security
- WIS security policies
- WIS environmental control policies

COMPETENCY 2: MANAGE THE OPERATIONAL APPLICATIONS

Prepare, plan, design, procure, implement and operate the applications required to support the WIS functions.

Many of these skills are generic ITC skills and will have already been attained as part of prior education and training or will be provided by applications suppliers.

Competencies components

1 Meet service levels by maintaining applications in optimal operational condition, through:
- configuration of applications
- monitoring and responding to applications' behaviour
- preventative and corrective maintenance
- replacement or upgrade of applications

2 Contingency planning, application backup and application restore

3 Ensure data integrity and completeness in the event of system failure

4 Ensure system security

Learning outcomes

You will be able to:
- Operate, configure and maintain applications
- Monitor applications and take corrective action
- Apply and test WIS security protocols

You will learn:
- WIS applications specific to your centre
- WIS system security policies and procedures

Learning activities

To learn how to perform these job tasks you may:
- Attend training by systems and other outside providers
- Initiate monitoring and reporting procedures and respond to typical monitoring reports
- Apply WIS site security measures and respond to typical incidents

Assessment

You must be able to:
- Configure and maintain system components
- Respond to monitoring reports
- Apply site security measures and respond to typical incidents

Underpinning knowledge and skills
- Current technologies and emerging trends
- WIS functions and requirements

- Recognized IT service management frameworks
- Service level agreements for your centre

Key learning resources

- Documentation of centre's applications
- WIS/GTS manuals and guides
- Tools to monitor system security
- WIS security policies

COMPETENCY 3: MANAGE THE DATA FLOW

Manage the collection, processing and distribution of data and products through scheduled and on-demand services.

Competencies components

1 Ensure collection and distribution of data and products as per data policy

2 Publish data and products

3 Subscribe to data and products

4 Encode, decode, validate and package data and products

5 Create, update and maintain data flow catalogues

6 Manage connectivity between centres

7 Control the data flow to meet service levels

Learning outcomes

You will be able to:

- Transfer data and products between your centre, other WIS centres, and external users
- Request data and respond to data requests using ad hoc and routine delivery mechanisms
- Maintain quality standards (service levels) by monitoring, and responding to, traffic flow, missing data and products, errors and service messages
- Apply relevant data policies to data and products
- Identify appropriate formats for data and product exchange
- Write and read data in WIS formats using your centre's tools

You will learn:

- Data representations used in WIS and when they are applicable
- WMO data policies and how data are associated with these in WIS
- The structure of the WIS and GTS and how to use reference documents to identify and interpret the routing plans and protocols you will need to use
- The interfaces of your centre's WIS applications, the information they use to modify their behaviour, and the tools available to control the operation of the applications to achieve service levels

- How to use a WIS centre interface to find and request data for delivery by ad hoc request and by subscription
- How WIS handles back-up and how the GTS handles alternative routings to maintain continuity of data flows

Learning activities

To learn how to perform these job tasks you may:

- Connect to a WIS centre to search for information, select a dataset, download a copy from the cache
- Using a WIS centre interface, create, modify and delete a subscription for routine delivery of a dataset
- Use the software tools used by your centre's WIS application to exchange information between computers
- Assess data flows by analysing monitoring reports from your applications
- Investigate how data policy (including WMO Resolutions 25 and 40) is applied to data published by your centre
- Use tools provided at your centre to view information in different formats and convert data between these formats

Assessment

You must be able to:

- Go to a WIS centre, find data, download it immediately, subscribe for regular delivery and cancel the subscription
- GTS component: Use a switch to move data between training computers and control the flow

Underpinning knowledge and skills

- Internet protocols
- Networking principles (local area networks and wide area networks) and associated monitoring and control technologies

Key learning resources

Data policies

- WMO Resolution 25 (Resolution 25 (Cg XIII) – Exchange of Hydrological Data and Products)
- WMO Resolution 40 (Resolution 40 (Cg-XII) – WMO policy and practice for the exchange of meteorological and related data and products including guidelines on the relationships in commercial meteorological activities
- Centre's data policies

GTS data exchange

- *WMO-No. 386 Manual on the Global Telecommunication System*
  - Attachment II-5 of the *Manual on the Global Telecommunication System* (data designators)
  - Attachment II-6 of the *Manual on the Global Telecommunication System* (format of addressed messages)
  - Attachment II-7 of the *Manual on the Global Telecommunication System* (routing catalogues)

  - Attachment II-15 of the *Manual on the Global Telecommunication System* (section on *FTP procedures and file naming convention*)
  - Attachment II-16 of the *Manual on the Global Telecommunication System* (procedures for transmitting and collecting meteorological bulletins using e-mail and web)

Data representations

- WMO-No. 306 *Manual on Codes – International Codes*, Volume I.1: *Part A – Alphanumeric Codes*
- WMO-No. 306 *Manual on Codes – International Codes*, Volume I.2: *Part B and Part C*
- Guidance on migration to table driven code forms (http://www.wmo.int/pages/prog/www/WMOCodes.html#Codes)
- Tools used at centre to read, write, convert, validate and display information in Table Driven Code Forms
- Sample data for reading and writing in Table Driven Code Forms

WIS discovery, access and retrieval

- WMO-No. 1060 M*anual on the WMO Information System*
  - Man on WIS (WMO-No 1060/Annex VII to WMO-No 49) Part 2 para 2.4.1, Part 3 para 3.4, Part 4 para 4.3, 4.11, 4.12, 4.13, Part 1 para 1.7), and the corresponding sections of the Guide to WIS.
  - WIS compliance specification Part 2 para 2.4.
- WMO-No. 1061 *Guide to the WMO Information System*
- User account at a GISC and PC with internet connection

Managing GTS data exchange

- *WMO-No. 386 Manual on the Global Telecommunication System*
- WMO-No. 9 *Weather Reporting*, Volume C1: *Catalogue of Metaeorological Bulletins*
- Global Telecommunication System routing tables
- Training environment on message and file switch
- World Weather Watch quantity monitoring statistics

Security of data exchange

- *WMO-No. 1116 Guide to Virtual Private Networks (VPN) via the Internet between GTS centres*
- WMO-No. 1115 *Guide to Information Technology Security*

Network management

- Network Management tool and associated documentation
- System error reports and event viewing tools

COMPETENCY 4: MANAGE THE DATA DISCOVERY

Create and maintain discovery metadata records describing services and information and upload to the WIS DAR catalogue

Each data and product record held within WIS must have metadata associated with it in order to be able to discover it and to know what it means. These metadata records are held in a catalogue for discovery, access and retrieval (DAR).

Competencies components

1 Create and maintain discovery metadata records describing products and services

2 Add, replace or delete metadata records within the catalogue

3 Ensure that all information and service offerings from a WIS centre have complete, valid and meaningful discovery metadata records uploaded to the catalogue

Learning outcomes

You will be able to:

- Create discovery metadata from user supplied descriptions using standard WIS tools
- Add, replace or delete metadata records within the catalogue

You will learn:

- The role of discovery metadata in discovery, access and retrieval of data and products
- Approved metadata formats
- How to discriminate content that is mandatory, acceptable or inapplicable
- Use of metadata creation tools
- How to access and modify a catalogue
- How data flows within and to and from your centre
- Tools to allow users to input descriptions

Learning activities

To learn how to perform these job tasks you may:

- Create metadata records based on sample descriptions for a range of data and products typical for your WIS Centre
- Insert these into a catalogue, replace them with records which have been changed, and delete them

Assessment

You must be able to:

- Demonstrate successful creation of metadata records for typical products
- Demonstrate competence in publishing and deleting metadata catalogue records

Resources

- WIS Technical Specifications: WIS-TechSpec-9: Consolidated view of distributed Discovery, Access and Retrieval metadata catalogues
- WMO-No. 1060 *Manual on the WMO Information System*, Part 5, Core Metadata Profile
- WIS metadata guidance
- Metadata entry and management tools
- Samples of how to complete typical examples
- Metadata policies and WIS metadata guidelines
- ISO 191xx series: ISO standards on Geographic Information

COMPETENCY 5: MANAGE WIS CENTRE-CENTRE INTERACTIONS

Manage relationships and compliance between your centre and other WIS centres

Competencies components

1 Exchange information with other centres on operational matters

2 Facilitate registration of new WIS centres

3 Facilitate registration of new data and products by other WIS centres

4 Create and respond to WIS service messages, including GTS

Learning outcomes

You will be able to:

- Facilitate registration of new WIS centres and their data and products
- Keep other WIS centres informed of the status of services, incidents and requests
- Monitor and respond to service levels reports
- Manage subscriptions

You will learn:

- Knowledge of current exchanges and requirements for notification of operational changes
- What type of data, products and services are available at your centre
- Procedures and practices for registration of other centres and their data and products
- Procedures and practices for notifying other centres about operational changes and service availability

Learning activities

To learn how to perform these job tasks you may:

- Perform the above activities using software, tools and guidance as used in your operational environment, either in a classroom environment or under supervision on-the-job

Assessment

You must be able to:

- Respond to a request to register a new centre and its data and products
- Prepare notifications of typical operational scenarios
- Respond to typical notifications from other WIS centres

Resources

WMO

- Manual on GTS (WMO no 386)
- Manual on WIS (WMO No 1060)
- Part II, Centre Nomination Procedures
- Part IV, WIS Techspecs 4, 6, 7, 8 & 13

- Guide to the WIS (WMO 1061)
- Weather reporting (WMO No 9)
- Exchange of Meteorological Data (WMO No 837) (Resolution 25 & 40)

Local

- Service Level Agreements (as used by your centre)
- FAQ Documents (User centric)
- WIS software user guides
- Guidelines for services available at WIS centre
- Data policy and associated guidance material
- First line support procedures and guides
- User database (for contact information)
- Tools (could be whiteboard)
- Case tracking and customer management
- WIS user management
- WIS subscription management
- WIS components monitoring dashboard

COMPETENCY 6: MANAGE EXTERNAL USER INTERACTIONS

Ensure users, including other centres, data providers and subscribers, can publish and access data and products through WIS

Competencies components

1 Register data providers and subscribers and maintain a service agreement

2 Set and register access criteria

3 Provide systems and support for users to publish and access data and products

4 Manage user relations to ensure a high satisfaction level

Learning outcomes

You will be able to:

- Register new WIS users and providers, setting roles, access authorizations and levels
- Create and amend WIS users subscriptions
- Use WIS tools to assist users and providers to resolve problems
- Create and respond to WIS service messages, including GTS
- Undertake first-line investigation and diagnosis
- Manage incidents and requests: log them, categorize and prioritize them, escalate as appropriate and close them when the user is satisfied
- Keep users informed of the status of services, incidents and requests.
- Gather and report on user and provider satisfaction
- Assist users to upload and access data
- Identify potential problems in services and implement improvements

You will learn:

- What type of data, products and services are available at your centre
- How WIS applications are intended to be used, including discovery, access and retrieval (DAR)
- How to apply data policies
- How to interact effectively with users and providers

Learning activities

To learn how to perform these job tasks you may:

- Register users (data providers and subscribers) and set access authorizations and levels using software, tools and guidance as used in your operational environment
- Role play user interactions

Assessment

You must be able to:

- Register typical data providers and users
- Ensure users are able to upload and access data
- Respond to typical incidents

Resources

WMO

- Manual on GTS (WMO No 386)
- Manual on WIS (WMO No 1060)
- Part II, Centre Nomination Procedures
- Part IV, WIS Techspecs 4, 6, 7, 8 & 13
- Guide to the WIS (WMO 1061)
- Weather reporting (WMO No 9)
- Exchange of Meteorological Data (WMO No 837) (Resolution 25 & 40)

Local

- Service Level Agreements (as used by your centre)
- FAQ Documents (User centric)
- WIS software user guides
- Guidelines for services available at WIS centre
- Data policy and associated guidance material
- First line support procedures and guides
- User database (for contact information)
- Tools (could be whiteboard)
- Case tracking and customer management
- WIS user management
- WIS subscription management
- WIS components monitoring dashboard

COMPETENCY 7: MANAGE QUALITY, RISK AND OPERATIONAL SERVICE

Ensure the quality and continuity of the service

This is essentially a management role, ensuring that the WIS system operates as it is required to do, now and into the future. Some of these skills are generic management skills, rather than WIS specific, and would be taught or learnt elsewhere.

COMPETENCY COMPONENTS

1 Coordinate all WIS functions and activities of the centre

2 Set and monitor Centre regulations, policies and procedures to meet quality and service performance standards

3 Ensure service continuity through risk management, planning and implementation of service contingency, service backup and service restore, and ensure data continuity in the event of system failure

4 Plan and coordinate the delivery of new functionality and improvements

5 Ensure budgets are set and met

Learning outcomes

You will be able to:

- Ensure the WIS centre meets quality and service performance standards
- Identify the challenges and issues to address
- Foster compliance with WIS framework

You will learn:

- Functions and responsibilities of WIS centre
- WIS quality and service performance standards
- Methods to manage quality, risk and operational service
- How to monitor quality and service performance standards
- How to analyse quality and service performance in the WIS centre
- How to report quality and service performance
- How to demonstrate quality and service performance
- How to maintain troubleshooting and backup and restore procedures
- How to plan and coordinate the delivery of new functionality and improvements
- How to integrate new technologies and developments
- How to update the regulatory documents
- How to maintain service agreements
- How to plan monitoring resources
- How to align budget restrictions with human resources demands

Learning activities

To learn how to perform these job tasks you may:

- Monitor quality and service performance standards
- Analyse quality and service performance in the WIS centre

- Report quality and service performance
- Demonstrate quality and service performance
- Maintain troubleshooting and backup and restore procedures
- Plan and coordinate the delivery of new functionality
- Keep timely records, as required

Assessment

You must be able to:

- Demonstrate successful WIS service
- Plan successful procurement of replacement and upgrade of equipment and applications to meet new functionality and requirements

Resources

- Technical Regulations (WMO-No.49), Volume I
- Resolution 25 (Cg-XIII)
- Resolution 40 (Cg-XII)
- *WMO-No. 386 Manual on the Global Telecommunication System*
- WMO-No. 1060 *Manual on the WMO Information System*, WIS-TECHSPEC-15 (Reporting of quality of service)
- WMO-No. 1061 *Guide to the WMO Information System*
- WIS demonstration process procedures and guidelines
- Monitoring reports
- Audit reports

Recommendation 22 (CBS-Ext.(2014))

PROVISION OF OPERATIONAL METEOROLOGICAL ASSISTANCE TO HUMANITARIAN AGENCIES

THE COMMISSION FOR BASIC SYSTEMS,

Noting that the Executive Council at its sixty-sixth session requested the Commission to review the governance procedures relating to the provision and availability of information on meteorological, hydrological and other environmental hazards, with a view to developing appropriate guidance for consideration by the Seventeenth World Meteorological Congress,

Noting further:

(1) The strategic priority afforded to Service Delivery issues for the seventeenth financial period,

(2) That the success of the Global Framework for Climate Services will depend on the effective delivery of climate services to a wide variety of users,

(3) The proliferation of non-authoritative sources of meteorological information accessible to the humanitarian agency community,

(4) The mission of WMO and the primary role of National Meteorological and Hydrological Services in providing warnings of severe weather in support of the safety of life and mitigation of damage to property,

(5) The request from the Executive Council at its sixty-sixth session that the Commission for Basic Systems and the Commission for Climatology consider the most appropriate and effective contribution to humanitarian agencies and the Early Warning Early Action Report of the Inter-Agency Standing Committee,

Considering the development of a liaison between WMO and the humanitarian agencies through the Commission for Basic Systems Task Team on the Provision of Operational Meteorological Assistance to Humanitarian Agencies, and the subsequent identification by the humanitarian community of its needs and requirements for operational meteorological and hydrological information and services,

Recommends that the roadmap outlined in the annex to the present recommendation be adopted and that the Commission coordinate the work with the other technical commissions in implementing the roadmap on behalf of WMO.

Annex to Recommendation 22 (CBS-Ext.(2014))

ROADMAP TO THE DEVELOPMENT OF GUIDANCE FOR THE PROVISION OF METEOROLOGICAL ASSISTANCE TO HUMANITARIAN AGENCIES

1. Requirements for operational meteorological and hydrological products and services by Humanitarian Agencies.

a. Humanitarian Agencies, like many other entities that operate in a global context, have a need for meteorological and hydrological information on **all** spatial **scales** from global to local, and all time scales from minutes to decades, as well as historical information;

Humanitarian Agencies would welcome an active and **sustained engagement** with the WMO community;

They need this information to be provided from one contact point (at global, regional and national levels) available 24/7 as required by their operational needs, presented in a consistent, easily-understandable manner, using narrative text and visuals, **tailored** to their specific needs (this is essential);

They need this provision of information to be augmented by consultation and **interpretation** to enable the full value of the information to be translated into efficient and effective action (this is essential);

They would like a mechanism to be established to facilitate **two-way communication** and exchange of information between the meteorological and humanitarian communities;

They would like information (data, warnings) to be readily available, ideally with appropriate metadata if possible; and for the information to be formatted for ingestion into commonly used systems (**geo-referenced**);

Training on meteorological/hydrological concepts is needed, which includes engagement with exercises, workshops and discussion fora;

They would welcome evaluation and verification of meteorological products and services as elements in the **validation** of authoritative advice.

2. Roadmap for what WMO needs to do in the short term to support Humanitarian Agencies

a. Realizing the diversity of humanitarian agencies in mission, focus, capabilities, and scale, establish a definition or description of humanitarian agencies for purposes of clearly establishing and gathering requirements;

b. Recognize and promote to the Humanitarian Agencies the strengths of the WMO community, such as:

   i. The harmonization of data policies;

   ii. The availability of information via WIS etc;

   iii. The activities, organizational structure and operations of the Global Data-processing and Forecasting System (GDPFS) at global, regional and national levels;

   iv. The advances in forecasting at all time scales, including the advent of operational seamless data-processing and forecasting;

c. Refine the requirements itemized in 1. above;

d. Clarify, and define where necessary, the responsibility of existing centres for the provision of products appropriate to the Humanitarian Agencies on global, regional and national scales, and develop protocols for provision of global and regional guidance to Humanitarian Agencies (see diagram below);

e. Design, create and test a mechanism for the delivery of services with the Humanitarian Agency community, taking into account their needs for consultation, interpretation and two-way engagement, and following best practices in collaborative decision-making and validation;

f. Recognizing the successful development of the meteorological and hydrological products and services (e.g. through the implementation of the Severe Weather Forecasting Demonstration Project (SWFDP), the Global Seasonal Climate Update (GSCU, on a trial basis), and the Flash Flood Guidance System (FFGS)), to request the relevant Technical Commission's Expert and/or Task Teams to assist in the development of the protocols mentioned in item c. above;

g. Strengthen the engagement of the WMO community with the Inter-Agency Standing Committee (IASC) by nominating a suitable representative(s), to assist with the preparation of the Early Warning / Early Action (EW/EA) report and to provide feedback both to the CBS Task Team and to the Members, as appropriate, where potential environmental impacts have been identified;

h. Recognizing the issues raised at EC-66 regarding the Global Disaster Alert Coordination System (GDACS), to engage with the EU JRC to promote access to, use of, and attribution of authoritative information sources on GDACS, while encouraging unofficial or experimental sources be clearly noted with proper caveats;

i. Organize a joint HA/WMO workshop in Geneva to:

   i. Perform a test phase with one region…;

ii. Begin to define training needs (including cross-training);

iii. Consult on the development of prototype services for the provision of operational meteorological assistance by NMHSs to HAs at a national level;

iv. Design and agree to propose to CBS Management Group the reporting and governance arrangements relating to the provision of information services from the WMO community to the Humanitarian Agencies;

v. Review and revise current arrangements exist for providing information to Humanitarian Agencies (as defined in Appendix I-5 of the *Manual on the Global Data-processing and Forecasting System* (GDPFS), WMO-No. 485) (as outlined in the diagram below), which may need to be re-invigorated, implemented and reinforced.

3. Roadmap for what WMO needs to do in the medium-to-long term.

a. Following continued validation and testing of the prototype, implement the mechanisms for the operational delivery of services as defined in 4d above;

b. WMO needs to keep in sight that meteorological conditions may impact significantly on non-meteorological crises;

c. Based upon clear requirements developed and identified in collaboration with humanitarian agencies, improve, as appropriate and needed, the supply of geo-referenced information and other metadata;

d. Provide guidance and assistance to Members in developing a legal framework that would strengthen and support the role of NMHSs as authoritative providers of warnings of high impact weather.

Recommendation 23 (CBS-Ext.(2014))

PROPOSED MECHANISM TO STRENGTHEN OPERATIONAL CENTRES, BUILT UPON THE LESSONS LEARNED THROUGH THE SEVERE WEATHER FORECASTING DEMONSTRATION PROJECT

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The *Abridged Final Report with Resolutions of the Sixteenth World Meteorological Congress* (WMO-No. 1077),

(2) The *Abridged Final Report with Resolutions of the Sixty-sixth Session of the Executive Council* (WMO-No. 1136),

(3) The *Final Report of the Extraordinary Meeting of the Steering Group of the Severe Weather Forecasting Demonstration Project (SWFDP)* (Geneva, 3–5 December 2013),

(4) The reports of the 2013 and 2014 Meetings of Presidents of Technical Commissions (January 2013 and 2014),

(5) The *Final Report of a Workshop to Assist in Sustaining National Meteorological Services – Strengthening WMO Regional and Global Centres* (Washington, D.C., 18–20 June 2013),

Noting further:

(1) That the Sixteenth World Meteorological Congress approved a vision for the Severe Weather Forecasting Demonstration Project as an end-to-end, cross-programme collaborative activity led by the Global Data-processing and Forecasting System,

(2) That Sixteenth Congress requested the Commission to continue to give high priority to the implementation of SWFDP and its expansion into all WMO Regions,

(3) That SWFDP has been either in implementation or in development in five regions (Southern Africa, South Pacific, Eastern Africa, South-East Asia and the Bay of Bengal), and under consideration for others,

(4) The results of a study requested by the Steering Group of the Severe Weather Forecasting Demonstration Project to scope the resource requirements for ensuring effective implementation and long-term sustainability of the benefits gained with SWFDP, starting from an evaluation of the resources utilized by SWFDP thus far,

Considering:

(1) The significant increase of resources, both budgetary and human, required to ensure effective implementation of multiple, simultaneously running projects, including crucial regular training and coordination and support by the Secretariat, and expansion of SWFDP to all WMO regional associations,

(2) That the expansion of SWFDP could only be realized with extrabudgetary contributions that have been provided either by Members or other organizations such as the World Bank and the United Nations Economic and Social Commission for Asia and the Pacific,

(3) That the WMO Resource Mobilization Office has been working with external partners in order to develop and sustain the appropriate extrabudgetary contributions in support of SWFDP, and that it has secured the necessary funds for the management and coordination of the regional SWFDP projects by the Secretariat for at least the next three calendar years,

Considering further the need:

(1) For dedicated human resources to coordinate and manage the Secretariat support for regional SWFDP projects, including tracking their implementation,

(2) For extending the range of and/or establishing synergies with targeted applications to broaden the benefits of SWFDP and framework to other user sectors such as agriculture, health, water and disaster risk reduction,

(3) For consolidating SWFDP into global sustainable operational services through an enhanced Cascading Forecasting Process,

(4) For strengthening operational centres,

Urges Members to continue to offer expert support to SWFDP and the expanded global programme or mechanism to support operational centres, and to provide staff secondments and/or loans for enhancing the Secretariat capacity;

Recommends the establishment of an expanded mechanism to support operational centres for the sustainability of the Cascading Forecasting Process, developed through a set of SWFDP projects and sustained with the support of a funded coordination office within the Secretariat, as described in the annex to the present recommendation.

Annex to Recommendation 23 (CBS-Ext.(2014))

PROPOSED MECHANISM TO STRENGTHEN OPERATIONAL CENTRES, BUILT UPON THE LESSONS LEARNED THROUGH THE SEVERE WEATHER FORECASTING DEMONSTRATION PROJECT

1. Summary

This document responds to the request from PTC for a Concept Paper towards a programme to strengthen operational centres, which would be built upon the lessons learnt through the SWFDP, as an end-to-end cross-programme collaborative activity that engages all WMO programmes and technical commissions. It proposes an expanded global programme or mechanism to support operational centres through the Cascading Forecasting Process, developed through a set of SWFDP projects and sustained with the support of a core funded programme office within the WMO Secretariat.

2. Background to SWFDP and its *Cascading Forecasting Process*

2.1 The Severe Weather Forecasting Demonstration Project (SWFDP) was initiated to enable all NMHSs to issue effective severe weather warnings to disaster management and civil protection authorities in their respective countries. Using a Cascading Forecasting Process, the Project makes global-scale products available to Regional Specialized Meteorological Centres (RSMC) that integrate and synthesize them in order to provide daily guidance for NMHSs in their geographical region. Thus, the NMHSs have greater capability to identify hazardous weather conditions in the short- and medium-range and issue forecasts and warnings accordingly. Because NMHSs in a geographical region typically need similar products, the Project makes efficiency gains by coordinating their requirements. Where possible, the limited bandwidth of many of the receiving NMHSs is taken into account, with the file sizes of guidance products being minimal.

2.2 The Project contributes to capacity building by helping developing countries access and make use of existing NWP products for improving hazardous weather warnings. It encourages operational forecasters to use relevant standard or newly developed products and procedures, which have already been introduced in many GDPFS Centres. The initial aim was to show how further cooperative work among operational meteorological centres could enhance the forecasting process of several types of severe weather phenomena, which in turn would improve the warning services provided by the NMHSs. However, the concept has evolved and the expected outcomes now include:

- Enhanced capability for NMHSs to forecast severe weather and issue warnings at the national level, including improved accuracy and longer lead-times;
- Established warning processes agreed with national disaster management and civil protection authorities, along with planned responses for protection of lives and property;
- Established forecast processes and Quality Management Systems (QMS), and strengthened forecast capabilities in support of other user sectors in society (such as agriculture and food security, aviation, marine safety and transportation, etc.) at the national level;
- Raised awareness of the value of NMHSs with national governments and their agencies, leading in the long-term to greater national support and investment and leading, in turn, to improved supply of observations and feedback into the GDPFS; and
- Reduced loss of life and damage to property and contributions to the Millennium Development Goals of eradicating extreme poverty and reducing child mortality.

2.3 The SWFDP is implemented in close collaboration with the Public Weather Services (PWS) Programme in order to improve severe weather forecasting and warning services. It has also been coordinating with other WMO technical commissions and programmes to extend the range of applications and broaden the benefits to other user sectors in society.

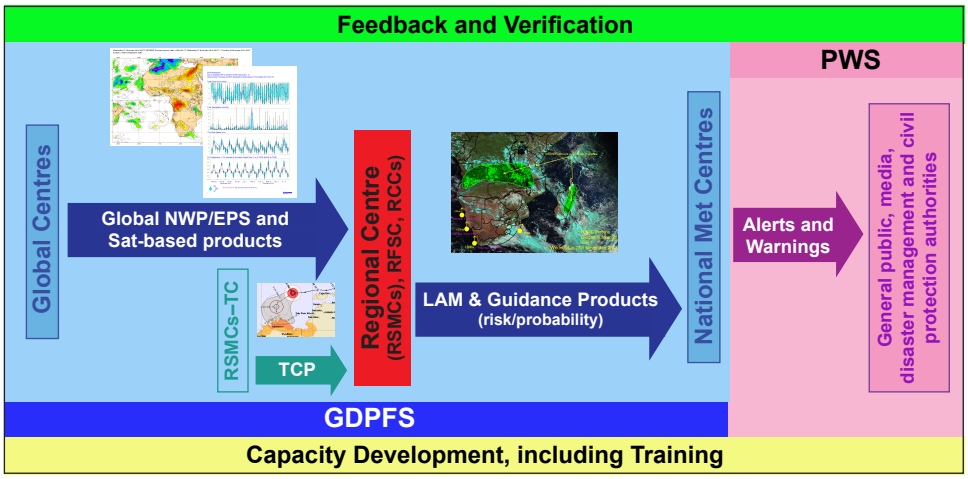


Figure – The *Cascading Forecasting Process* of the SWFDP.

2.4 Projects which have successfully made the transition to fully operational status conduct near real-time verification and evaluation, based on observations of meteorological parameters collected at local meteorological stations and information gathered on the impacts of the severe weather phenomena. Evaluation of the performance of the cascading process, including the quality of the NWP/EPS and guidance products, are provided as feedback to the participating centres to further fine-tune the process and products.

2.5 Regular training is a critical component of the Project. Forecasters need to know how to make optimal use of the various products coming from the GDPFS Centres. Training is also carried out in service delivery principles and practices including user focus, communication skills and user satisfaction assessment.

2.6 The SWFDP continues to experience important benefits and significant growth. Five regional projects are either underway or under development – Southern Africa, South-west Pacific, Eastern Africa, Southeast Asia and Bay of Bengal/South Asia. Future plans include the transitioning of existing SWFDP regional projects into sustainable Severe Weather Forecasting Operations (Phase 4[1]) and the establishment of the SWFDP service in further geographical areas. The ultimate goal is for all NMHSs to issue effective severe weather warnings to disaster management and civil protection authorities in their respective countries. This would enhance capability in providing hydro-meteorological forecasting and warning services in support of disaster risk reduction, and take a range of other applications to a new level. This is aligned with the WMO Capacity Development Strategy (Objective 5), and would assist in sustaining the linkages between regional and national centres in their geographical regions; as well as global to regional relationships.

3. Expansion of SWFDP to a Global Mechanism or Programme to Strengthen Operational Centres

3.1 The SWFDP as a demonstration project has demonstrated the value of the Cascading Forecasting Process in strengthening NMHSs, supporting their capability to issue severe weather warnings and to build effective relationships with disaster management and civil protection

[1] Phase 4 is a "Continuous Development Phase" aimed at sustainability of the SWFDP concepts within the regional early warning system. It focuses on transferring oversight to the region, broadening the activities of the SWFDP to other areas/activities and ensures sustainability of the concept to avoid a fall-back to the previous status where NMCs do not have access to advanced forecasting technologies.

authorities for disaster risk reduction. This had led the World Meteorological Congress, at its sixteenth session (Cg-XVI, May 2011), to agree that SWFDP should be an end-to-end cross-programme collaborative activity that engages with all WMO programmes that concern the real-time prediction of hydro-meteorological hazards, through their respective technical commissions: from observations, to information exchange, to delivery of services to the public and a range of targeted applications/user sectors, education and training, capacity development and support to LDCs, and to the transfer of relevant promising research outputs into operations. This paper proposes a concept for the development of that programme.

3.2 The SWFDP develops regional projects in a phased approach, with three phases of development and demonstration followed by a transition to sustainable operations in Phase 4. In order to provide the resources to support expansion to cover additional regions towards global coverage, and to maintain a sustainable service in the regions which have reached Phase 4, the project should become a strategic programme of WMO supported by core funding and a permanently staffed Project Office. The SWFDP will continue to be guided by a Steering Group led from the CBS/DPFS, but now involving all relevant technical commissions and programmes.

3.3 It is proposed that this programme should be named the Severe Weather Forecasting (SWF) programme which would still retain a close link with the well-established acronym, SWFDP (Severe Weather Forecasting Demonstration Programme) during Phases 1–3. There is also a strong emphasis on operational capability through the term forecasting.

3.4 The SWF programme will provide a major contribution to WMO High Priorities:

- Disaster risk reduction;
- Capacity development of NMHSs;
- GFCS, through increased climate change resilience;
- In addition SWF will exploit and reinforce both WIGOS and WIS by capacity building of NMHSs, and as a vehicle to assess the gaps in the Basic Systems, including WIGOS and WIS, for effective warnings' services.

3.5 Development of synergies with other WMO programmes to provide end-to-end coupling with weather-related hazards is set out in section 3 below, but the core of the programme supports the capability of NMHSs to forecast severe weather. This in turn provides a core contribution to an integrated strategy for disaster risk reduction.

3.6 The success of the SWFDP has been based on an approach starting from a regional management team addressing regional needs, and employing a regional centre to provide forecast guidance to NMHSs in the region through the Cascading Forecasting Process, supported by global centres as required. This approach should continue for the development of new projects in new regions to expand the service towards global coverage. Such SWFDP projects are well-suited to donor funding to transfer the capacity in a region. However, to ensure sustainable operations after the initial development and demonstration period, and to coordinate the work of many regional services as the core of a WMO strategy for disaster risk reduction, requires a strategic programme with core funding and the support of a dedicated project/programme office. As described in item 2.5 (above), training support and coordination are key requirements of the programme office, to ensure the provision of central training from global and regional centres, and guidance units.

3.7 The functions of the regional centre will define the requirements of a designated RSMC with geographical specialization, and will be specified within the Manual of the GDPFS. A regional centre will be required to demonstrate compliance with these requirements and to be designated as an RSMC before the project can move from SWFDP demonstration phase to Phase 4 operational service. Thereafter RSMC status will be reviewed at regular intervals (e.g. every 4 years) to ensure continued compliance. RSMCs will be expected to support the core capabilities and operational functions of the RSMC with national funding. Additional functions, including significant enhancements to RSMC systems and capabilities, may be suitable for donor funding.

3.8 Projects, which have completed the three development and demonstration phases of SWFDP and are in a position to become fully operational will require a number of non-operational activities to be supported and funded to ensure they are sustainable. These activities include:

- Regional ownership;
- Strategic leadership;
- Management meetings around every 2 years;
- Training for RSMC and NMHS staff at least every 2 years
  - Supplemented by e-learning facilities
  - On-site training in NMHSs may be less frequent;
- IT development including website and product upgrades;
- Monitoring, evaluation and reporting – annually;
- Country-specific support to improving benefit realization available in all countries;
- Administrative and logistics support for meetings and training;
- Resource mobilization.

There should be a regional entity responsible for ensuring all countries achieve and maintain compliance and oversee programme management and related aspects with continuing support from the Severe Weather Forecasting (SWF) programme office.

3.9 To support the non-operational activities of the SWF programme, and also the development of new SWFDP projects to expand the programme towards global coverage, the SWF programme office is expected to require 2 full-time staff initially, and this level is expected to require a modest increase as the number of regional projects and services increases.

3.10 New SWFDP projects should generally be supported by donor funding. Three different models are proposed for preparing SWFDP projects towards the Phase 4 transition to sustainable service, depending on the status and capabilities of the RSMC. Examples are given of regional SWFDPs or potential SWFDPs which might be suitable for support under each of these models:

- Sustaining and strengthening existing RSMCs;
  - SWFDP South Pacific supported by RSMC Wellington which is still in Phase 3 has been unable to secure the services of a suitable regional identity to resource a sustainable future;
- Expanding the role of relevant RSMCs with activity specialization in Tropical Cyclone Forecasting;
  - SWFDP Bay of Bengal supported by RSMC New Delhi;
- Establishing RSMC support for the Cascading Forecasting Process in all areas – this may be achieved by developing new Regional Forecasting Support Centres (RFSC)[2] which subsequently achieve RSMC designation, or by redefining a RSMC with existing geographical specialization;
  - Southeast Asia, with regional centre at RFSC Ha Noi;
  - South America, with regional centre at RSMC Brasilia;
  - Central Asia, with the support of RSMC Moscow or RSMC Novosibirsk;
  - West of the existing SWFDP South Pacific project area, with regional centre at RSMC Darwin or by development, a new RSMC Jakarta.

[2] "Regional Forecasting Support Centre (RFSC)" does not have a defined status within the GDPFS structure, but is the name of a centre that is carrying out the regional severe weather forecasting functions in the development and demonstration phases of the SWFDP, which will achieve RSMC designation with the transition of SWFDP to operations (phase 4), when this centre would be fully functioning.

4. Potential synergies with and involvement of other technical commissions and programmes

4.1 The PTC, at its 2013 meeting, also requested proposals for the expansion of the SWFDP with future directions towards a programme to strengthen operational centres. This section proposes a number of examples of links with other WMO programmes and Technical Commissions, and some ideas for how they might exploit the Cascading Forecasting Process or similar methods, for consideration by the PTC. The PTC is invited to suggest how to improve the description of links with their respective technical commissions.

4.2 Standards and guidance established by WMO are effectively implemented by WMO Members through projects like the SWFDP, in particular in developing new capacities, benefiting from new technologies, managing change and developing appropriate mentoring schemes. The success of the SWFDP is in part because it takes a holistic, regional-driven approach, i.e. through improving the entire end-to-end chain from production to the delivery of warning services to the users, through the "Cascading Forecasting Process". Coordination with the Regional Programme (RP) – Regional Offices, including the Programme for LDCs, Education and Training Programme (ETR), Voluntary Cooperation Programme (VCP), and the Resource Mobilization Office (RMO), in the planning and implementation of regional projects has been (is) critical to ensure that desired, sustainable and relevant outcomes are achievable.

4.3 In particular, the Regional Programme (RP) and the Programme for Least Developed Countries (LDCs) could contribute to:

- Provide ownership and requirements for cascading process;
- Contributions to regional management teams and resource mobilization.

It is therefore important to engage Regional Associations (RAs), including groupings of directors of NMHSs within the regional and sub-regional economical bodies (i.e. comprising Heads of Meteorological Services and Ministries in charge of meteorology) from early stages, to address their requirements and to ensure regional endorsement, ownership, implementation and sustainability (including recognition of SWFDP as a contributing mechanism for the implementation of their meteorological development plans and investment strategies).

4.4 And the Education and Training programme (ETR) could continue to contribute with the following aspects:

- Support training activities for cascading process;
- RTCs should deliver training for the programme;
- E-learning;
- Cascading process gives NMHS forecasters access to products which allows training to be reinforced by usage;
- Competencies for forecasters support forecasting across many disciplines.

4.5 The appropriate use of the existing *Cascading Forecasting Process*, which is well described in the SWFDP Guidebook and Overall Project Plan, would contribute to strengthening operational functions of GDPFS centres, especially the RSMCs, in other programmatic activities, and by using the structures realizing the *Cascading Forecasting Process*, to also strengthening links with appropriate other national and regional hydro-meteorological activities. It is, therefore, proposed that exploiting methods similar to the *Cascading Forecasting Process* across different programmes could help to develop an integrated approach to collaboration with disaster management organizations for effective response to hydro-meteorological warnings. This would require the expansion of the existing concept of the *Cascading Forecasting Process* to provide a wider set of best practice guidelines for implementation of the *Cascading Forecasting Process* across other programmatic themes (e.g. hydrology, marine, agrometeorology, aviation, etc.), and possible involvement of the relevant WMO Technical Commissions and Programmes (as exemplified in paragraphs below).

4.6 The SWFDP regional projects represent the regional infrastructure to support national warnings programmes, including in collecting and conveying the requirements for the "Basic Systems" (including coordination with WIGOS and WIS), while addressing aspects related to severe weather forecasting and warning services (e.g. this is the case for the SWFDP – Eastern Africa, where issues related to observational and telecommunication aspects are being considered/addressed). Examples of possible engagement of the other CBS OPAGs and CIMO include:

- WIGOS
  - SWFDP E.g. regional centres could collect (radar) observations and provide composite mapping products which would support the work of the RSMC;
- WIS
  - SWFDP Support to enhance data collection;
  - SWFDP Explore options for exchanging information between NMHSs and RTHs;
- SAT
  - SCOPE-NWC Nowcasting to support SWFDP with nowcasting capabilities;
  - Distribution of global and regional centre products through GEONETCAST;
- Observations from WIGOS and SAT used in verification of severe weather forecast.

4.7 Among the main challenges for the SWFDP, has been the need for very short-range forecasting (including nowcasting) tools, especially to address the rapid onset of localized severe thunderstorms that produce heavy precipitation and strong winds, in the absence of adequate real-time observational networks, especially in absence of weather radar coverage. In this context, following the outcome of the first phase of the SWFDP in Southeast Africa (in 2008), coordination has been established with the WMO Space Programme (SAT) to ensure that satellite-based products are available through each SWFDP regional project. Satellite-related training, satellite information (data and products) and dissemination mechanisms to support the SWFDP are now core component of the SWFDP (see also item 4.6 above). These products made available through the SWFDP also contribute to aeronautical meteorology (AeM).

4.8 The SWFDP regional projects also represent a systematic approach for building capacity and for transferring knowledge and skills to NMHSs, especially to weather forecasters. Their framework has been used to implement a series of proven or modernizing enhancements to the forecasting process, as well as to provide a channel for the transfer of relevant promising S&T research and development outputs through trials, such as from the WWRP/THORPEX TIGGE project "Global Interactive Forecast System" (GIFS), and involves the WWRP/SERA to support effective propagation of benefits to society. Other examples include:

- Establish synergies with the planned High-Impact Weather (HIWeather) project, which aims to develop new forecast and weather impact tools, and seek to trial them with SWFDP as an operational platform and link to end-users;
- Link with Sub-seasonal to Seasonal (S2S) project for seamless forecasts;
- Continue to implement new verification methods through the SWFDP;
- Strengthen synergies with the Nowcasting research activities, including the Lake Victoria project.

4.9 Presently, four of the five SWFDP regional projects include NMHSs of countries that are within the footprint of Tropical Cyclone basins. Synergies (including specific collaboration and joint development work) are being established with the Tropical Cyclone Programme (TCP), and its Regional Bodies. In particular, TCP:

- Provides a vital input to the SWFDP Cascading Process;
- Cascading Process supports communication of impacts of Tropical Cyclone forecasts to PWS.

4.10 As described in item 2.3 (above), the SWFDP is implemented in close collaboration with the Public Weather Services (PWS) programme in order to improve severe weather forecasting and warning services, and support the Disaster Risk Reduction (DRR) programme as the cascading process provides framework for DRR support in many vulnerable countries.

4.11 SWFDP has also been coordinating with other WMO Technical Commissions and Programmes to extend the range of applications and broaden the benefits to other user sectors in society. In relation to synergies with the Commission for Hydrology (CHy) *[please note that similar approaches may be applicable for the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) and the Commission for Agriculture Meteorology (CAgM), for example]*:

- The Cascading Forecasting Process may also be usefully applied from regional to national level in flood forecasting;
  - Onward Communications of warnings and collaboration with DRR organizations should be done collaboratively with SWFDP;
- Rainfall (and other) forecasts from GDPFS systems should provide a key input to hydrological forecasts and flash flood forecasts;
  - May be shared at both regional and national levels;
- Rainfall maps compiled by CHy provide a useful source of observations for use in SWFDP cascading process and verification;
- Flood forecasts provide a useful guidance to assess the likely impact of heavy rain forecasts.

4.12 In addition, in relation to JCOMM, CAeM and CAgM:

- Access to products and data through cascading process helps with compliance with standards (e.g. for aviation forecasting), and it reinforces training;
- Extend the forecast guidance to longer timescales for Food security;
- Propagate NWP (important meteorological and other weather-related parameters) into high-impact models for specialized forecasting (e.g. flash floods, coastal flood forecasting, large waves, etc.), including synergies with the Coastal Inundation Forecasting Demonstration project (CIFDP).

4.13 In relation to the Commission for Climatology (CCl):

- GPCs for Long-range Forecasts (LRF) and RCCs/RCOFs could also provide a very similar cascading forecasting process;
- Aim for a seamless process across timescales by collaboration between RCCs and RSMCs;
  - Develop working arrangements;
  - Coordinated approach to work with regional humanitarian organizations;
  - Coordinated approach to Weather and Climate Watch;
- Contribution to GFCS.

4.14 Finally, SWFDP contributes to the WMO Quality Management Framework (QMF) through supporting efforts in NMHSs in their implementation of Quality Management Systems (QMS).

Recommendation 24 (CBS-Ext.(2014))

STANDARDIZATION OF DATA MANAGEMENT PRACTICES

THE COMMISSION FOR BASIC SYSTEMS,

Noting that Members rely increasingly on sharing both historical and near-real-time information,

Noting further:

(1) That the Intercommission Coordination Group on the WMO Integrated Global Observing System, endorsed by the Executive Council at its sixty-sixth session, identified a need for standard guidance on managing data throughout its life cycle,

(2) That development of the WMO Information System has concentrated on the exchange of information,

(3) That the use of electronic systems to gather, store and distribute information provides opportunities to broaden the use of data, but also introduces risks to the data that need to be managed,

(4) That the *International Meteorological Vocabulary* (WMO-No. 182) provides a valuable source of definitions for use in data management and WMO Technical Regulations, but that it has not been revised since 1992,

(5) That there are no common WMO standards for data management,

(6) That Members providing data to centres that offer to maintain the data expect that the integrity, availability and accessibility of the data will be managed to an appropriate standard,

(7) That operating a data archive centre is potentially expensive, and that Members offering to provide such facilities will expect to know the requirements being placed upon them,

Recommends:

(1) That the Commission lead a cross-cutting effort, across all technical commissions, to coordinate development of guidance for Members in relation to the effective management of data throughout their lifecycle;

(2) That the scope of the WMO Information System be extended to include provision of guidance on data management;

(3) That an Intercommission procedure be set up, guided by the Executive Council, to update and maintain the *International Meteorological Vocabulary*;

(4) That the Commission investigate the requirements for a standard method of identifying objects within WMO;

(5) That the scope of the WMO Information System be extended to include setting and auditing standards for centres that hold information in support of WMO Programmes, to be known as Part C of the WMO Information System.

ANNEXES

ANNEX I
Annex to paragraph 2.2.5 of the general summary

WMO TECHNICAL NOTE 170 (TN170) DOCUMENT FRAMEWORK PLAN

Working title of the revised TN-No. 170:

"Meteorological and Hydrological Aspects of Siting and Operation Nuclear Power Plants" (revised Edition, 2014 *(WMO-No. XXXX)*

1. Background Objective Scope

- ref: last paragraph in Preface of SSG-18)
- what this document fulfils (needs, e.g. in SSG-18)
- target audience for this document
- define "assessment of hazards" (quantification, characterization of hazard, observation of the phenomena, plausible scenarios)

Objective: This technical manual is to provide a practitioner, in meteorological, hydrological and climatologic sciences, guidance on how to utilize global resources and state-of-the-art practices, in the development of information that can be used in the assessment of site specific hazards and the capabilities of the site in responding to any emergency situation that may occur at the site.

The manual provides the technical basis for implementing the guidance provided in the IAEA Safety Series Guide 18"……." And provides processes and methodologies that can be utilized to not only meet the intent of the IAEA document SSG-18 but in addition supports compliance with the requirements of IAEA Safety Requirement document NS-R-3

The current manual supersedes earlier WMO documents TM 170 Volumes 1 & 2 and is restructured to provide the technical guidance needed by Member States to implement the intent and safety objectives of the IAEA documents on this subject as it relates to nuclear installation sites.

2. Structure of the document, and organizational roles

WMO, including collaboration with IAEA and national counterparts

Role of NMHSs

GFCS

IPCC (AR-5)

3. Necessary Information – meteorological and hydrological assessment
(common elements for sections, can be described with a generalized process flow chart)

3.1 Generic specifications: which variables, temporal and spatial extents

3.2 Observations (instruments, networks, locating of met tower (mandatory) and flow gauging station (if necessary), data collection, metadata, historical records/events)

3.3 Data Analysis (normals, extreme events, rare events, data quality, long series of records, good practices)

3.4 Meteorological (NWP) Re-Analysis (what's available, global, down-scaled to regional scale, parameters that are useful for data analysis and limitations)

3.5 Climate prediction and projection

3.6 Estimating uncertainties (generic text, from Flood Forecasting Manual, and WMO-No. 1091)

3.7 Tailored climatological products (e.g. climate indices)

3.8 Sources (and access) of relevant meteorological and hydrological information and products (GFCS service delivery, users interface, context)

3.9 Communication of information (terminology, e.g. probabilities, data exchange with NMHS for QA/QC and integrated into regional meteorological context)

3.10 Periodic review and update (IAEA minimum every 10 years)

4. Assessment of Meteorological Hazards

4.1 Extreme meteorological phenomena (air temp, wind speed, precipitation, snowpack)

4.2 Rare meteorological phenomena (lightning, TC, tornadoes, waterspout, precipitation/PMP)

4.3 Other meteorological phenomena (dust storm, hail, freezing precipitation and frost)

4.4 Transport, dispersion and deposition of airborne radioactivity, incl. source term estimate (new to SSG-18)

5. Assessment of Hydrological Hazards

5.1 Extreme flood events (storm surges, wind generated waves and seiches, flash flooding, compounding)

5.2 Rare flood events (e.g. PMF, dam break, *tsunami a contributing factor*)

5.3 Low flow risk

5.4 High ground water levels

5.5 Water contamination (leakage of contaminants to ground water, surface water contamination is already accounted for by standard engineering practices)

6. Design Basis Parameters

6.1 Meteorological

6.2 Hydrological (floods)

6.3 Software solutions

7. Measures for Site Protection – generalized response, related to mitigation by suitable infrastructure against identified hazards, as per SSG-18

8. Potential Future Changes in Hazards

8.1 Climate Change and Hazards (regional, air and water temperatures, water levels, temporal range)

8.2 Other changes (geographic, geomorphic)

8.3 Social changes (land use)

9. Monitoring, Forecasting, and Warning Systems for the Protection of Installations

9.1 Meteorological monitoring

9.2 Meteorological forecasts and warnings

9.3 Hydrological monitoring

9.4 Hydrological forecasts and warnings

9.5 Operational atmospheric dispersion and emergency response

10. Conclusion

– Summary relative to objective and scope

– Monitoring Systems and Warning Systems for Protecting the General Public (process to be undertaken by national government)

Appendix

– an example, for one hazard(s), using the flow diagram, to illustrate the methodologies for assessment of the hazard.

ANNEX II
Annex to paragraph 2.2.8 of the general summary

SUMMARY OF THE CHANGES OF FUNCTIONS AND PROCEDURES TO THE CURRENT *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485)

The new Manual is changed from the current version of the Manual in several overall respects:

- The overall structure is revised as discussed below. This simplifies the structure as the old Manual had evolved over many updates.
- The Manual is designed so that it can be modified as frequently as necessary to keep it up-to-date. While Part I should be rather stable and seldom require updating, it is expected that the evolution of science, technique, and user requirements, will continue to induce developments requiring frequent changes to Parts II and III.
- Volume II is discontinued.
- A full list of the sections from the current version of the Manual which have been included and excluded is provided in the Table at the end of this Annex.

Structure

The description of the Functions of the GDPFS is replaced with a “framework for the sharing of data related to operational meteorology, hydrology and climatology”. This is more focused on activities, outputs and benefits compared to the old Manual which was more focused on general functions.

The new Manual is organized under a new structure of three Parts as follows:

- Part I, Outline of the WMO GDPFS, presents the overall purpose of the GDPFS, its organization and the general characteristics of the various activities to be performed. It makes a distinction between general purpose activities and specialized activities: general purpose activities are those which encompass essential data processing required for a wide range of end-usage, e.g. global NWP or seasonal and climate numerical prediction, while specialized activities are those for which data processing is tailored for a specific type of application or user community, e.g. marine, environmental emergency, etc.
- Part II, Specification of GDPFS activities, gives detailed information on the various activities: mandatory functions including production, verification and documentation, and additional recommended functions and products. It also specifies overall requirements applicable to all types of activities, regarding dissemination, verification, training etc.

- Part III, GDPFS implementation, presents the status of implementation of the GDPFS from the user's point of view: table of performed activities with indication of the participating centres, as well as from the producer's point of view: table of GDPFS centres with indication of the performed activities.

Scope

The new Manual extends the scope of the GDPFS beyond the WWW (World Weather Watch) to encompass other real-time activities as requested by the Executive Council at its sixty-fifth session:

> "The Council reinforced that, similarly to the WIGOS and WIS, the GDPFS is an all-encompassing system, including data-processing and forecasting systems coordinated by CBS, jointly with other technical commissions and/or WMO Programmes, as well as with other international organizations. It agreed that the GDPFS is the basis for the operational production of accurate, reliable and timely weather, climate, water and related environmental forecasts and products, and would therefore satisfy, in a cost-effective and sustainable manner, the evolving data-processing and forecasting requirements of WMO Members. Noting that the evolution of the GDPFS goes beyond the data-processing and forecasting systems of the WWW, the Council requested the Secretary-General to develop an amendment for consideration by EC-66 to reflect these aspects in the WMO Technical Regulations (WMO-No. 49)."

The additional activities are:

- Numerical ocean wave (in collaboration with JCOMM)
- Storm surge prediction (in collaboration with JCOMM)
- Numerical ocean prediction (in collaboration with JCOMM)
- Response to marine environmental emergencies (in collaboration with JCOMM)
- Activities related to Hydrology and Agriculture (in collaboration with CHy and CAgM respectively)
- Activities related to polar regions (on request from EC-PORS)
- Provision of meteorological assistance to humanitarian agencies
- Space weather (in collaboration with CAeM and SAT)
- Operational air quality forecasting (in collaboration with CAS and CBS/OPAG-IOS)

Quality Management

The functions and activities of a World Meteorological Centre (WMC) are unchanged. The new Manual takes into account the evolving structure of the GDPFS, including the rapid growth in capabilities of GDPFS Centres over recent years, and facilitates the designation of additional centres.

The new Manual introduces principles of Quality Management as requested by the Commission for Basic Systems at its fourteenth session:

> "6.3.55 The Commission noted that Volume I of the Manual on the GDPFS does not provide guidelines for reviewing the status of RSMCs with activity specialization However, RSMCs with activity specialization in Atmospheric Transport Modelling and Global Producing Centres for Long-range Forecasts have established procedures for monitoring, and providing information on, ongoing compliance. The Commission requested the OPAG on DPFS to consider generalization of these principles to RSMCs with other types of activity specialization."

In line with quality management requirements, the bodies in charge of managing the information contained in the *Manual* are explicitly specified for every type of GDPFS activity. This is done in Part II.2, through Tables labelled “Responsibility” (cf. example hereafter), where:

– the three lines under “Changes to activity specification” indicate the team(s) and bodies in charge of preparing specification updates, approving them, and deciding to update the *Manual* accordingly;

– the two lines under “Centres designation” indicate the bodies responsible for approving the designation of a GDPFS centre for the activity under consideration and for deciding accordingly;

– the two lines under “Compliance” indicate the team(s) and bodies in charge of ensuring that the designated GDPFS centres remain compliant with the activity specification.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-OFPS		
To be approved by:	CBS		
To be decided by:	EC / Congress		
CENTRES DESIGNATION			
To be approved by:	CBS		
To be decided by:	EC / Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-OFPS		
To be reported to:	CBS/ICT-DPFS	CBS	

Designation of Centres

The new Manual introduces clear definitions of the functions of WMCs and of several types of RSMCs, and describes a process for regular compliance assessment of RSMC and WMC status.

The term WMC is no longer restricted to specific defined centres. Following Quality Management principles, any centre which meets the required criteria in terms of functions, activities and compliance assessment processes may be designated as a WMC.

The term RSMC is used as a general term for a designated centre. There have always been a number of different types of RSMC, but the list is expanded to include several more types of specialization. A number of types of centre with other names including RCC (Regional Climate Centre), GPC (Global Producing Centre for Long-Range Forecasts) and LC (Lead Centre) are also types of RSMC. Such centres may be referred to using both the specific names (RCC, GPC, LC) and/or the general term RSMC.

Definitions of RSMCs:

- RSMC with geographical specialization is discontinued. Replaced with several new RSMC designations with appropriate required activities and compliance assessment processes:
  - RSMC for Regional Severe Weather Forecasting (SWFDP-like)
  - RSMC for Global NWP
  - RSMC for Limited Area NWP

– RSMC for Global EPS

– RSMC for Limited Area EPS

The definition of a geographical Region (for example, the area of responsibility of an RSMC performing limited area NWP) is not specified in a general way in the Manual, so the decision is made on a case-by-case basis and depends on the context and requirements for regional support. Information on the areas covered by specific centres is provided in Part III of the Manual.

The concept of RSMC for Regional Severe Weather Forecasting originates from the model of the SWFDP Regional Centre. The SWFDP provides a framework for the development of a Regional Centre providing severe weather support to NMHSs in a region. In the final phase of the SWFDP the project transitions from demonstration phase to sustainable operations, and at this stage the regional centre could be designated as RSMC for Regional Severe Weather Forecasting. Outside of established SWFDP projects, a Centre which has consistently demonstrated, over a sustained period, all the required capabilities for Regional Severe Weather Forecasting in collaboration with associated NMCs may be designated as an RSMC with the specialization of Regional Severe Weather Forecasting.

The new Manual requires Members of WMO to support an NMC and defines the minimum functions of an NMC.

Volume II

Volume II of the current version of the Manual, which covered Regional Aspects, is discontinued and the relevant sections are incorporated in the new Manual, following the request by Cg-16:

> "Resolution 6 (Cg-16): REVISED *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485) THE CONGRESS,
>
> (...)
>
> **Decides further**:
>
> That Volume II of the Manual (Regional Aspects), which has no regulatory status for Members, should be reviewed and the relevant parts, including the Regional Climate Centre (RCC) network composition, as well as a list of products and the possibility of designating one or more Regional Specialized Meteorological Centres (RSMCs) for polar regions, should be incorporated into the revised Manual. "

REVIEW OF THE EXISTING CONTENT OF THE MANUAL ON THE GDPFS

Volume / Part / Section / Paragraph	Not kept	Kept	Reviewed/ changed	Comments
Introduction			X	Changed following the new outline of the Manual
Volume I – GLOBAL ASPECTS				
Part I – ORGANIZATION AND FUNCTIONS OF THE GDPFS				
1. Purpose of the Global Data-processing and Forecasting System (GDPFS)			X	Changed following the new outline of the Manual
2. Functions of the GDPFS			X	Reviewed and redistributed within the new structure of the Manual
3. Organization of the GDPFS	X (1st para)	X (2nd para)		To remove: "The GDPFS shall be organized…" To keep: "The GDPFS shall also support…"

Volume / Part / Section / Paragraph	Not kept	Kept	Reviewed/ changed	Comments
4. Functions of GDPFS centres			X	To remove sections: 4.1.1, 4.1.2.1, 4.1.2.3, 4.1.2.4, 4.1.2.5, 4.1.2.6, and 4.1.3.1 RSMC with Geographical Specialization will become simply an RSMC – the geographical aspect will arise through the products and guidance delivered (e.g. RSMC Pretoria in the SWFDP) To include the following in "Section 4.1.2 RSMC:" "RSMCs will carry out activities from one or more of the following lists: 4.1.2.1 General Purpose Activities" (This covers the operational NWP as described in the proposed new outline) Section "4.1.2.2 Centres with activity specialization" – the list should be synchronized with the list included in the proposed new outline Section "4.1.3 NMCs" – this should be retained and reviewed. It needs to include mention of connection to the GTS/WIS
Appendix I-1 Location of WMCs and RSMCs with geographical specialization and RSMCs with activity specialization	X			To be replaced by part 3 of the proposed new structure of the Manual
Appendix I-2 Procedures for broadening the functions of existing RSMCs and for designation of new RSMCs	X			To be replaced by part 2, section 3 of the proposed new structure of the Manual. To add the possibility of creating a new centres.
Appendix I-3 Regional and global arrangements for the provision of transport model products for environmental emergency response			X	To be reviewed and redistributed within the proposed new structure of the Manual. To merge Appendices I-3 and I-6. To keep only mandatory aspects; guidance aspects should be in the Guide on ERA (available at: http://www.wmo.int/pages/prog/www/DPFSERA/td778.html)
Appendix I-4 Definitions of meteorological forecasting ranges		X		
Appendix I-5 Arrangements for the provision of meteorological assistance to United Nations humanitarian missions			X	To be reviewed based on the input from the CBS Task Team on the Provision of Meteorological Assistance to Humanitarian Agencies
Appendix I-6 Regional and global arrangements for atmospheric backtracking			X	To be reviewed and redistributed within the proposed new structure of the Manual. To merge Appendices I-3 and I-6. To keep only mandatory aspects; guidance aspects should be in the Guide on ERA (available at: http://www.wmo.int/pages/prog/www/DPFSERA/td778.html)
Attachment I.1 Guidelines to review the status of RSMCs with geographical specialization	X			
Attachment I.2 Procedures for the elaboration of observational data requirements	X			This is defined in the Manual on GOS (WMO-No. 544) Part II, Requirements for Observational Data, which describes the Rolling Review of Requirements process.

Volume / Part / Section / Paragraph	Not kept	Kept	Reviewed/ changed	Comments
Part II – DATA-PROCESSING AND FORECASTING ASPECTS				
1. Functions of WMCs, RSMCs and NMCs			X	
1.1 GDPFS products and services			X	To replace with tables of minimum products
1.1.1 Real-time products and services for middle latitudes and subtropical areas			X	To replace with the list of minimum products
1.1.2 Real-time products and services for tropical areas			X	To review
1.1.3 Non-real-time products and services			X	
1.2 Functions of Members responsible for GDPFS centres			X	
1.2.1 Interpretation at NMCs			X	
1.2.2 Accessibility of products	X			To refer to the Manual on WIS
1.2.3 Data management	X			To refer to the Manual on WIS
1.3 WMC responsibilities	X			
1.3.1 Output products	X			
1.3.2 Use of products	X			
1.4 RSMC responsibilities			X	To modify in light of the proposed new RSMC structure
1.4.1 Output products			X	
1.4.2 Binary/character conversion capabilities for transmission			X	
1.4.3 Constraints for adjacent centres			X	
1.5 Members' responsibilities		X		
1.5.1 NMC functions			X	
1.5.2 Checking of collected information	X			Definitions to be sent to METEOTERM. Rest of the text to the Manual on WIS
1.5.3 The functions of an NMC should also include the following non-real-time activities			X	To modify in light of the new structure of the Manual
2. Quality control of observational data and their reception at GDPFS centres in real- and non-real time	X			To refer to the WIGOS standards or the Manual on GOS. Need to check that there is also mention of the error bar around the measurement as this is important for quantifying the uncertainty within the NWP analysis. This information could be included in a Guide, but it is not relevant for a Manual
2.1 Quality control of observational data	X			
2.1.1 Definitions	X			
2.1.2 Responsibility for real-time quality control	X			
2.1.3 Minimum standards	X			
2.2 Requirements for observational data	X			
2.3 Times of receipt of observational data	X			
3. Analysis and forecasting practices	X			This information could be included in a Guide, but it is not relevant for a Manual
3.1 Reference surfaces for upper-air analysis	X			
3.2 Preparation of upper-air charts	X			

Volume / Part / Section / Paragraph	Not kept	Kept	Reviewed/ changed	Comments
3.3 Short-range weather forecasting	X			
4. Practices for pictorial representation of information on meteorological charts and diagrams	X			This information may be in the Manual on Codes. Anyway, this information should not be included in the Manual, but it could be in a Guide
4.1 Scales and projections of meteorological charts	X			
4.2 Symbols used on meteorological charts	X			
4.3 Construction of aerological diagrams	X			
4.4 Preparation of charts and diagrams for facsimile transmission	X			
4.4.1 Preparation of charts	X			
4.4.2 Standardization of maps for facsimile transmission	X			
4.4.3 Colours and features	X			
4.4.4 Legend	X			
4.4.5 Plotted data	X			
4.4.6 Analysed data	X			
5. Exchange of products between centres	X			To refer to Manual on WIS
5.1 Times of availability of products	X			
5.2 Programmes of output products	X			
5.3 Transmission priorities for GDPFS products	X			
5.3.1 Transmission priorities for global model products from WMCs and RSMCs	X			
5.3.2 Transmission priorities for regional model products from RSMCs	X			
5.3.3 Transmission priorities after transmission outages on the MTN and its branches	X			
5.3.4 Transmission priorities for global model products from WMCs and RSMCs after outages	X			
5.3.5 Transmission priorities for regional model products from RSMCs after outages	X			
5.3.6 Priority of observational data over processed data	X			
5.3.7 Transmission of products in binary, alphanumeric and pictorial form	X			
5.3.8 Plan for monitoring the operation of the World Weather Watch	X			
5.3.9 Procedures and formats for the exchange of monitoring results	X			
5.3.10 Standards in the provision of international services by Regional Specialized Meteorological Centres (RSMCs) for atmospheric transport	X			

Volume / Part / Section / Paragraph	Not kept	Kept	Reviewed/ changed	Comments
modelling in radiological environmental emergency response				
5.3.11 Standards in the provision of international services by Regional Specialized Meteorological Centres (RSMCs) for atmospheric transport modelling in backtracking	X			
5.4 Responsibilities of Members for providing information on their real-time data-processing activities	X			
Appendix II-1 Minimum standards for quality control of data for use in the GDPFS (both real-time and non-real-time)			X	To refer to WIGOS documentation (specific sections); introduced or referred to a Lead Centre
Appendix II-2 Observational data requirements for GDPFS centres for global and regional exchange	X			This is included in the RRR process, including the SoG which is a gap analysis
Appendix II-3 Times of receipt of observational data	X			This is obsolete – it is included in the Manual on WIS (GISCs specifications)
Appendix II-4 Graphical representation of data, analyses and forecasts		X		
Appendix II-5 Times of availability of products with high operational priority	X			Obsolete. This should be in the Manual on WIS
Appendix II-6 Overall list of output products required for international exchange from GDPFS centres			X	To be reviewed and redistributed within the proposed new structure of the Manual.
Appendix II-7 Users' interpretation guide for atmospheric transport model products provided by RSMCs		X		To keep up-to-date (ongoing review)
Appendix II-8 Designated Global Producing Centres for Long-range Forecasts and designation criteria		X		To be redistributed within the proposed new structure of the Manual.
Appendix II-9 Products provided by RSMCS with activity specialization in atmospheric transport modelling (backtracking for CTBT verification support)		X		To be redistributed within the proposed new structure of the Manual.
Attachment II.1 List of global model output products whose preparation should be given highest priority by WMCs and RSMCs	X			
Attachment II.2 List of regional model output products whose preparation should be given highest priority by RSMCs	X			
Attachment II.3 Transmission priorities for global model products from WMCs and RSMCs	X			
Attachment II.4 Transmission priorities for regional model products from RSMCs	X			
Attachment II.5 Transmission priorities after outages	X			

Volume / Part / Section / Paragraph	Not kept	Kept	Reviewed/ changed	Comments
Attachment II.6 Minimum product list for transmission in binary, alphanumerical and pictorial form	X			
Attachment II.7 Plan for monitoring the operation of the World Weather Watch			X	To refer to WIGOS and WIS as appropriate. To review it within the proposed new structure of the Manual
Attachment II.8 Standardized verification system (SVS) for long-range forecasts (LRF)	X			To associate it with the Lead Centre SVS LRF
Attachment II.9 Procedures and formats for the exchange of monitoring results			X	To associate it with the Lead Centre
Part III – DATA MANAGEMENT ASPECTS				
1. Storage of data	X			To refer to the Manual on WIS
2. Collection, archiving and retrieval of data in the GDPFS	X			
2.1 Data to be stored for non-real-time uses	X			
2.2 National arrangements for storage of climatological data	X			
2.3 Collection of data to be stored	X			
3. Non-real-time quality control	X			
3.1 Quality control of data to be stored	X			
4. Classification and cataloguing of stored data	X			
4.1 Catalogue of stored data	X			
5. Media and formats for the exchange of stored data	X			
5.1 Media for exchange	X			
5.2 Formats	X			
5.3 Responsibilities of Members for the exchange of non-real-time data	X			
Attachment III.1 Data to be stored at WMCs	X			
Attachment III.2 Data to be stored at RSMCs	X			
Attachment III.3 Minimum standards for non-real-time quality control	X			
Attachment III.4 Guidelines for storage and retrieval of satellite data	X			
Volume II – REGIONAL ASPECTS				
Region I (Africa)	X			Relevant parts to be included in the new Manual. A separate Volume to be discontinued
Region II (Asia)	X			
Region III (South America)	X			
Region IV (North America, Central America and the Caribbean)	X			
Region V (South-West Pacific)	X			
Region VI (Europe)	X			
The Antarctic	X			

ANNEX III
Annex to paragraph 2.3.9 of the general summary

TERMS OF REFERENCE OF THE TASK TEAM ON AVIATION XML

(a) To define the weather and climate information that must be represented in the aviation XML standard;

(b) To identify the key characteristics required of the aviation weather XML standard to allow consistency with the emerging WMO data model and existing examples of best practice e.g. EUROCONTROL WXCM, and that will allow consistent evolution alongside other WMO data representations to avoid duplication of effort and inconsistencies;

(c) To identify how the aviation weather XML standard can be maintained over a 50 year lifetime (METAR has been used since 1968) in an environment where it is used within embedded avionics;

(d) ~~To create a draft standard for the conjoint ICAO/WMO meeting in 2014 (June) in a state that will allow meaningful testing by the aviation community and the supporting manufacturers~~To create XML representations of information to support Amendments 76 and 77 to WMO-No. 49 Vol 2 (Annex 3 to the Convention on International Civil Aviation);

(e) To create a final standard in line with ICAO requirements that takes account of the lessons learned during testing;

(f) To set up mechanisms for the creation, operation and maintenance of any catalogues, registries or similar that are required to support the aviation weather XML standard;

(g) To create and provide the necessary regulatory and supporting materials for the aviation weather XML standard to be implemented;

(h) To define and maintain the WMO Logical Data Model ("METCE");

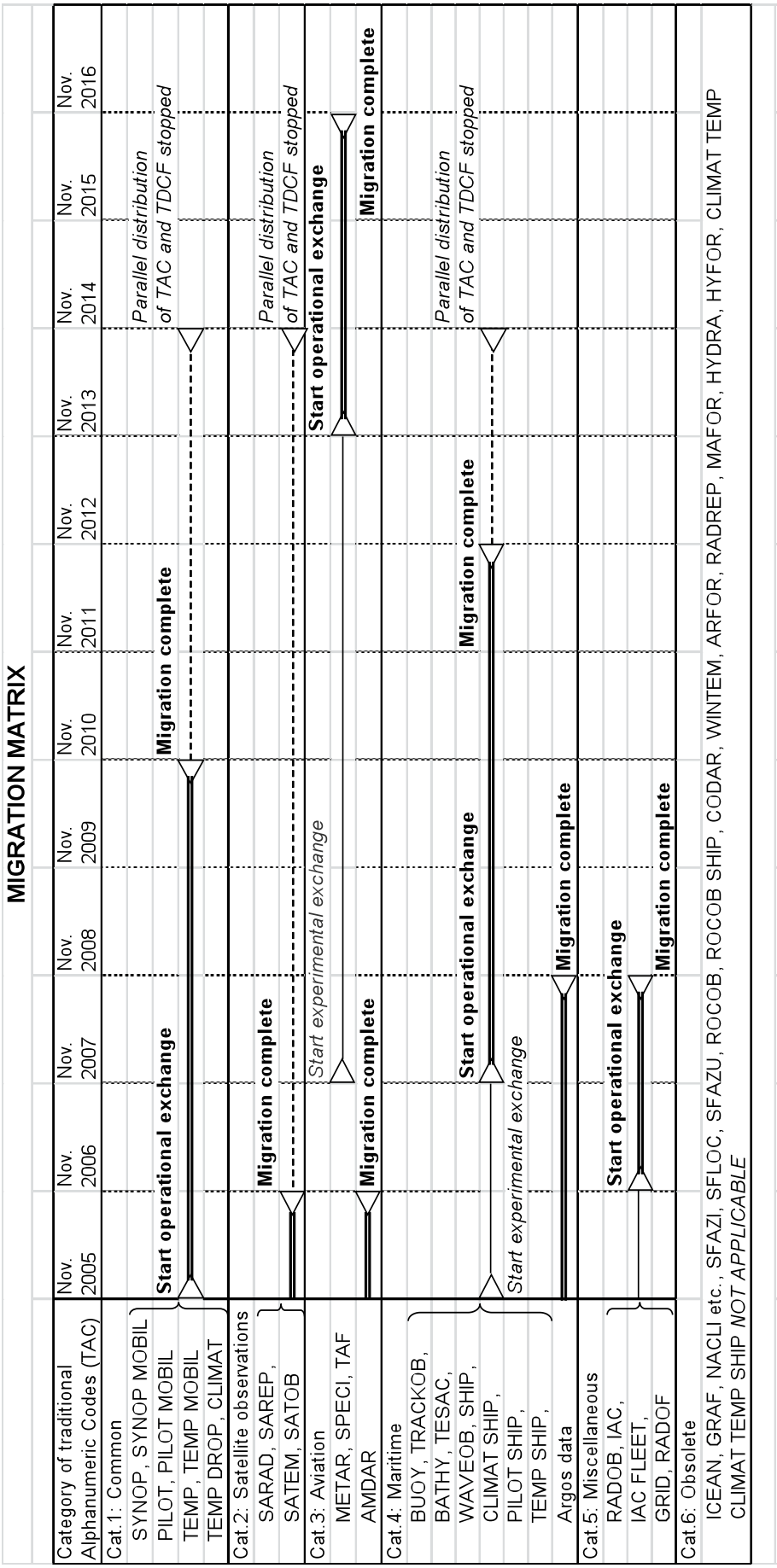
(i) To support CAeM in the creation and delivery of an implementation plan to develop the capacity of WMO Members to use the XML representation of aviation information;

(j) To coordinate activities with the CAeM Expert Team on Information and Services for Aviation.

This work to develop the additional representations to support Amendment 77 is expected to take three years, with two meetings each year: an editing meeting with a limited number of participants and a full meeting together with telephone conferences for development. Each member of the team will be expected to contribute about two months of work to the development each year. Further, additional resource will be needed to deliver the implementation plan.

ANNEX IV
Annex to paragraph 2.3.16 of the general summary

MIGRATION MATRIX


MIGRATION MATRIX
Category of traditional Alphanumeric Codes (TAC)
Nov. 2005
Nov. 2006
Nov. 2007
Nov. 2008
Nov. 2009
Nov. 2010
Nov. 2011
Nov. 2012
Nov. 2013
Nov. 2014
Nov. 2015
Nov. 2016
Cat.1: Common
SYNOP, SYNOP MOBIL
PILOT, PILOT MOBIL
TEMP, TEMP MOBIL
TEMP DROP, CLIMAT
Start operational exchange
Migration complete
Parallel distribution of TAC and TDCF stopped
Cat.2: Satellite observations
SARAD, SAREP,
SATEM, SATOB
Migration complete
Parallel distribution of TAC and TDCF stopped
Cat.3: Aviation
METAR, SPECI, TAF
AMDAR
Start experimental exchange
Start operational exchange
Migration complete
Cat.4: Maritime
BUOY, TRACKOB,
BATHY, TESAC,
WAVEOB, SHIP,
CLIMAT SHIP,
PILOT SHIP,
TEMP SHIP,
Argos data
Start experimental exchange
Start operational exchange
Migration complete
Parallel distribution of TAC and TDCF stopped
Cat.5: Miscellaneous
RADOB, IAC,
IAC FLEET,
GRID, RADOF
Start operational exchange
Migration complete
Cat.6: Obsolete
ICEAN, GRAF, NACLI etc., SFAZI, SFLOC, SFAZU, ROCOB, ROCOB SHIP, CODAR, WINTEM, ARFOR, RADREP, MAFOR, HYDRA, HYFOR, CLIMAT TEMP
CLIMAT TEMP SHIP NOT APPLICABLE

ANNEX V
Annex to paragraph 2.5.2 of the general summary

TERMS OF REFERENCE OF THE EXPERT TEAM ON SATELLITE SYSTEMS

The Expert Team on Satellite Systems (ET-SAT) shall:

(a) Assess and document, in the framework of the WMO Rolling Review of Requirements, the actual and planned capabilities of operational and R&D satellites constituting the space-based component of WIGOS and their adequacy to meet the WMO requirements for satellite data and products. This will be achieved in considering the information provided by participating agencies as well as the outcome of CGMS and CEOS, including e.g. the progress of CEOS constellations; the feedback from WMO should be communicated to CGMS and CEOS.

(b) Provide technical advice on implementation of integrated satellite observing systems.

(c) Assess progress of R&D and demonstration satellite systems, and identify opportunities and/or problem areas concerning satellite technology and plans.

(d) Coordinate with IPET-SUP and other relevant CBS teams on satellite related matters.

ANNEX VI
Annex to paragraph 2.5.2 of the general summary

TERMS OF REFERENCE OF THE INTER-PROGRAMME EXPERT TEAM ON SATELLITE UTILIZATION AND PRODUCTS

The Inter-Programme Expert Team on Satellite Utilization and Products (IPET-SUP) shall:

(a) Monitor the progress of satellite data availability and use by WMO Members, related issues and expectations, with the aim to publish findings and recommendations in a WMO document;

(b) Provide advice and support to the development and implementation of WIGOS, from a satellite user's perspective and coordinate with ET-SAT and IPET-OSDE on the evolution of the space-based component of Global Observing Systems;

(c) Initiate and promote activities to improve the availability of operational and R&D satellite data according to user needs, monitor these activities in close coordination with the relevant working group(s), regional associations and with WIS activities;

(d) Review present and future R&D satellite data and products including their availability and potential applications, and provide advice with a view of increased utilization by WMO Members;

(e) Review, and assist in addressing, the needs of WMO Members, WMO Technical Commissions and Programmes, and Regional Associations for information regarding satellite capabilities and in particular access to and utilization of satellite data and products;

(f) Promote development and harmonization of satellite data and products responding to WMO Members' needs;

(g) Keep under review the needs of WMO Members for training in satellite meteorology and related fields, and engage with the Management Group of the Virtual Laboratory for Education and Training in Satellite Meteorology (VLab) to address these needs, towards full utilization of satellite data from operational and R&D satellites, in accordance with the 2009–2013 Virtual Laboratory Training Strategy;

(h) Holding joint and/or overlapping meetings with ET-SAT as appropriate, to facilitate interaction between users and providers of satellite systems, data and products;

(i) Coordinate with ET-SAT with a view to making recommendations and receiving input on matters, such as the exchange, management, and archiving of satellite data and products, radio frequency utilization, as well as education and training and other appropriate capacity-building measures related to the use of satellite data in all WMO Programmes;

(j) Coordinate with WMO Technical Commissions and Programmes, including co-sponsored Programmes, activities related to satellite utilization and products, through ex-officio membership on the Team.

Note: The additions to the former ET-SUP Terms of Reference are underlined.

ANNEX VII
Annex to paragraph 2.5.13 of the general summary

OUTLINE OF THE UPDATED SATELLITE DATA DISSEMINATION STRATEGY FOR IMPROVED AVAILABILITY OF SATELLITE DATA AND PRODUCTS

1. STATEMENT OF NEEDS

1.1 The WMO 2012 Survey on the Use of Satellite Data

- Trend in the usage of satellite data:
  - 80% of respondents state that their overall use of satellite data is increasing, across all regional associations and all application areas;
  - This trend is driven by many different factors, like demise of in-situ networks, new application areas, increased quality of satellite products, progress in NWP assimilation or increasing demand for value-added services that depend on satellite products.
- Access to satellite data:
  - Globally 40% of respondents however stated that “accessing data in near-real-time” is a challenge for the use of satellite data;
  - This figure showed strong regional variability from 32% for RA VI to 65% for RA V users and 72% to RA III.
- Discovery of satellite data:
  - Globally 39% of respondents also stated that “Knowledge of available data” is a challenge of the use of satellite data;
  - This figure showed marked regional variability from 31% for RA VI to 46% for RA I, 50% for RA III and 53% for RA V.
- Resources for exploiting satellite data:

– Globally 64% of respondents stated that “resources (personnel, training, tools, etc.)” was a challenge for the use of satellite data;

– This figure showed strong regional variability from 55% in RA IV to 78% in RA III and 83% in RA V.

1.2 Expected benefits

- To all WMO Members: secure the value chain for satellite data usage, enabling all WMO members to exploit the full benefits of satellite data;
- To satellite data users: enhance the capabilities to access satellite data and products, in today’s and tomorrow’s technical environment, and help optimize their investments for data access;
- To satellite operators: to guide future developments of the application component of their ground segment, and to reach out to a wider user community.

2. BACKGROUND: IGDDS ACHIEVEMENTS, CHALLENGES AND OPPORTUNITIES

2.1 Evolution of the IGDDS concept

- The initial scope of the Integrated Global Data Dissemination Service (IGDDS) adopted by CM-4 and EC-LXI in 2004 was to address the data access challenges in considering “an IGDDS that builds on the “Alternative Dissemination Methods” concept (global dissemination service for satellite data and products based on DVB-S standard with telecommunications satellites)”;
- With the emergence of the WIS, the scope of IGDDS was widened in 2006 to ensure that space-based observation data and products would be handled in an integrated manner with the other (non-space) data;
- Furthermore it was recognized, that the so-called “ADM” (i.e. the use of DVB-S services) should not exclude other means such as Direct Broadcast or terrestrial networks or Internet. Direct Broadcast should continue to play important roles in addition to DVB-S services, especially for real-time access to LEO data;
- Finally, IGDDS was defined in the IGDDS Implementation Plan (V 2, November 2007) as the whole circulation scheme of satellite data & products, in compliance with WIS standards, with an overarching goal to enhance data access by WMO Members. Achieving worldwide dissemination of satellite data and products by DVB-S services, as documented in the DVB-S Operator standard for IGDDS, remains a core objective, but without being limitative.

2.2 IGDDS achievements

- A regional dialogue on Data Requirements has been initiated and formalized in most of the regional associations, framed by Resolution 12 (EC-65) and recommended by CBS-15;
- The WMO Space Programme became a regular contributor to the NAEDEX-APSDEU meetings on satellite data requirements for NWP;
- A range of rebroadcast services in DVB-S standard has been established operationally, and is coordinated through the GEONETCast Implementation Group. A DVB-S Operator Standard for IGDDS has been developed (2009);
- A RARS Operator Standard document was developed and RARS coding recommendations are maintained. The RARS network has nearly completed its initial objective (ATOVS relay over 90% of the globe) and was presented to the satellite sounding community through posters and presentations at International TOVS Scientific Conferences;

- On-going WIS implementation, in particular regarding monitoring and metadata and catalogue standardization;
- IGDDS and RARS Implementation Groups were established and had four successful joint meetings in 2007 to 2012. RARS meetings were held in 2013 and 2014. A Task Force on Satellite Data Codes was established and has provided input to the ISS Expert Team on Data Representation and Codes;
- On-line resources have been established to document the data available (web page and the Products Access Guide).

2.3 New Challenges

- Remaining difficulties for many users to access satellite data;
- New user communities for satellite data (ocean, space weather, …);
- Increasing relevance of R&D satellite data for operational applications;
- Need to consolidate and coordinate data access methods. There are various technical options to access data, but this causes dispersion of efforts;
- Future LEO and GEO satellite systems will cause an explosive development of data volumes, also posing particular challenges for regional and global data exchange;
- The high-volume satellite data represent a particular challenge for the WMO objective of integration of all information systems under the umbrella of WIS;
- Increasing pressure on Radio-frequency spectrum for direct broadcast;
- Fast evolution of dissemination-relevant technologies, increased need to anticipate changes in the technology landscape.

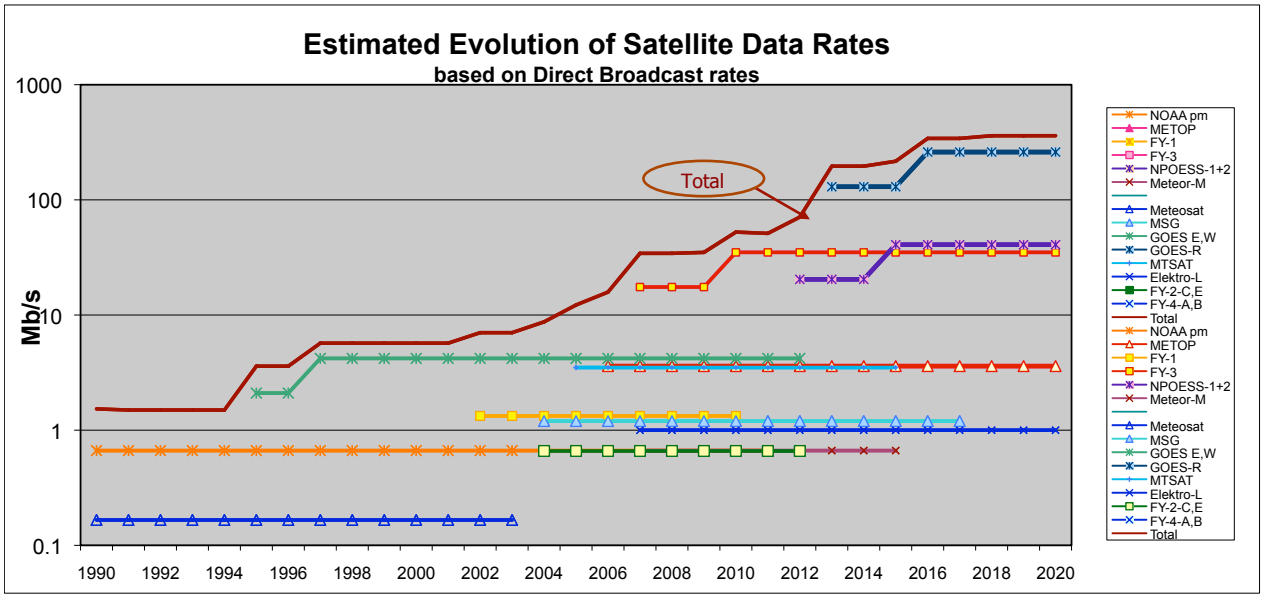


Figure 1: Evolution of raw data rates generated by satellite systems (semi-log scale) over 3 decades.

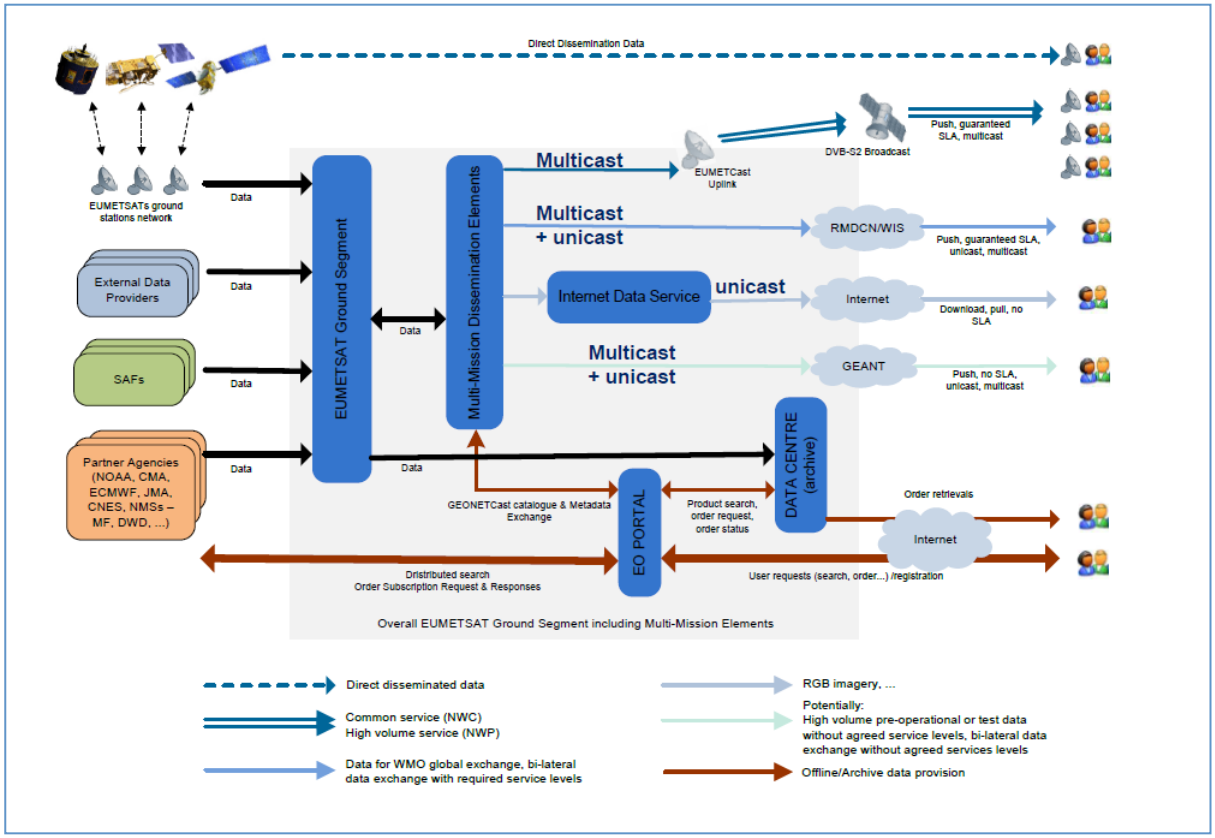


Figure 2: State-of-the art future Multi-Mission Data Provision Infrastructure (Courtesy of EUMETSAT)

2.4 Data/Product usage scenario

- General trend for increased use, but with different types of usage;
- Massive data use by NWP: data exchange optimization – mainly low-level data, stringent timeliness constraints, expanding range of data (atmosphere, ocean, chemistry, land surface);
- Widespread use of full-resolution data as required for product development/generation, though no longer systematic: focus on thematic areas of competences;
- Increased sharing of products: implied transparent validation and documentation (QA4EO);
- Emerging use of “virtual workplaces” (See ESA CCI Phase 2) for high-volume data sets;
- Some high-timeliness low-connectivity users require adequate products and services, e.g. in developing countries, or small island countries exposed to tropical cyclones.

3. STRATEGY REFORMULATION

Whilst the main priorities outlined in the IGDDS Implementation Plan remain valid, it is appropriate after 10 years to reformulate the guidance to satellite data dissemination and access, in a broader and updated perspective now termed Satellite Data Dissemination Strategy (SDDS).

3.1 Scope

- The new direction to satellite data dissemination and access needs to be communicated to a wide range of parties, including the “satellite” and “WIS” worlds and user communities;

- Most of the actions are relying on satellite data providers, in coordination with CGMS and the WIS world, which makes it difficult to determine and maintain a comprehensive action plan like the former IGDDS Implementation Plan;
- We should instead, on one hand, describe a Vision with high-level goals to be agreed upon by CGMS and WIS stakeholders and, on the other hand, define a limited set of focused, measurable actions with identified responsible entities (Secretariat and specific expert teams);
- The effort to enhance data access and dissemination is now reformulated as a new, broad strategy.

3.2 Technical opportunities for a new strategy

- The commitment of CGMS members to continue coordinating Direct Broadcast standards for LEO as exemplified in last update for the new X-band LEO DB services;
- Increased use of DVB-S2 for SATCOM rebroadcast;
- New momentum to expand the RARS projects, including NOAA DBRTN initiative for NPP-JPSS;
- Increasing capacity and functionality of terrestrial networks;
- Space agencies are reconsidering their ground segment strategy to better take into account user needs and technology evolutions;

  Examples: HimawariCast system being established by JMA, or the planned multi-mission data access architecture from EUMETSAT (Fig. 2).

3.3 SDDS vision and strategic targets

- The new Satellite Data Dissemination Strategy (SDDS), includes:
  - A vision;
  - Strategic targets realizing the vision;
  - Strategic activity threads for the realization;
  - A concept for overseeing the strategy implementation.
- Vision: Timely and reliable access through the WIS to all satellite data and products needed to meet the operational needs of all WMO Members.
- This vision will be realized through the specific targets:
  - Regional and thematic dialogues maintaining data requirements;
  - Re-broadcast DVB services available in all Regions and integrated in WIS;
  - Globally required satellite data provided to the WIS core network;
  - Exchange of other satellite data and products between Regions;
  - Use of appropriate, standardized formats;
  - Global coverage of LEO Direct Readout Acquisition and Relay systems;
  - Globally coordinated Direct Broadcast from LEO and GEO;
  - Routine access to required data and products from R&D satellites;
  - Dissemination providers acting as WIS DCPC, by providing coordinated data discovery, data access and data retrieval (DAR) for all satellite data;

– On-demand access to satellite data and products through the WIS;

– Information and guidance to users.

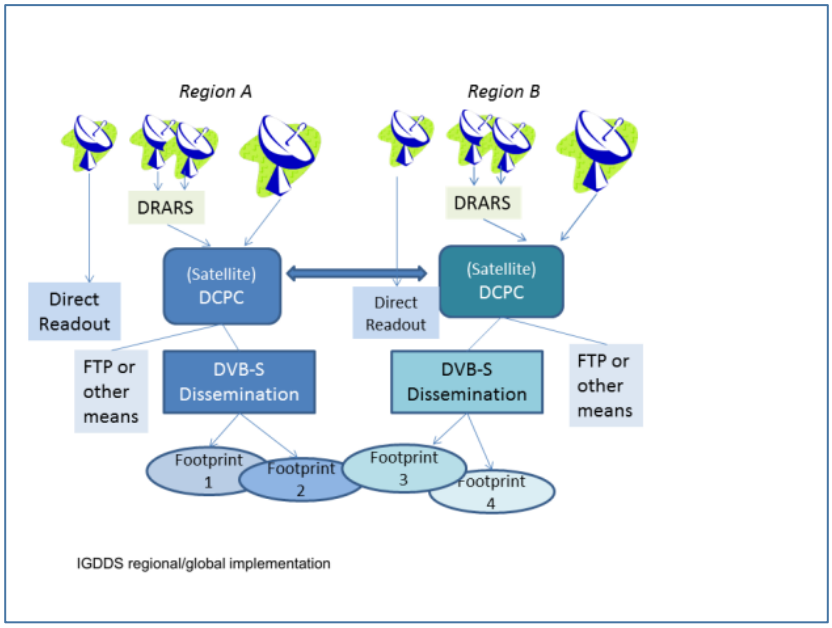


Figure 3: SDDS Regional and global components

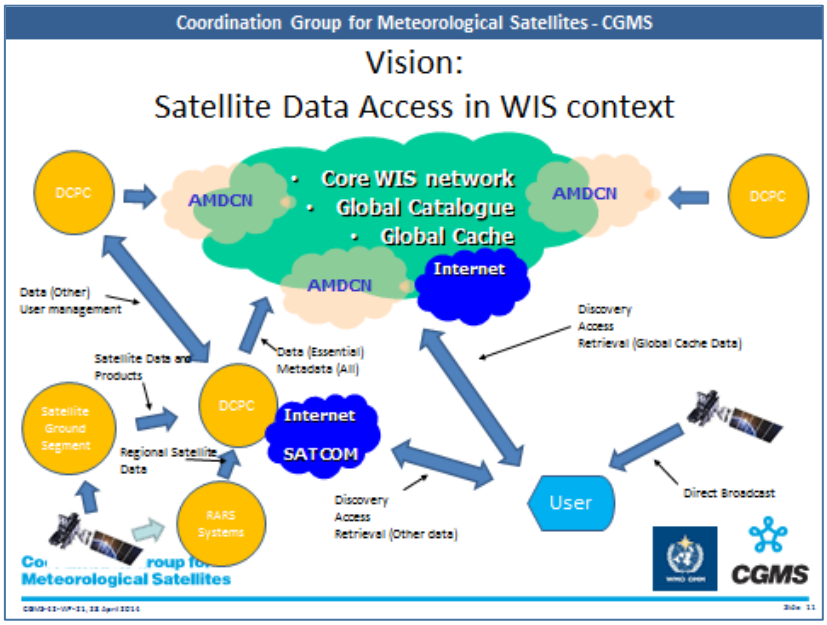


Figure 4: Vision of satellite data access in WIS context

4. STRATEGIC GUIDANCE AND REPORTING

While the original IGDDS project was focusing on one particular objective, to set up a range of DVB-S broadcast systems, the current strategy aims to a more comprehensive and balanced approach, which is also more complex. Only concerted action with multiple stakeholders in a number of different areas will realize the vision.

WMO Space Programme shall ensure regular consultation of satellite data providers and users, and report to relevant WMO bodies on the progress of implementation, based on strategic indicators. The process should also be informed by some technology watch to check that advantage is taken of relevant emerging ICT capabilities.

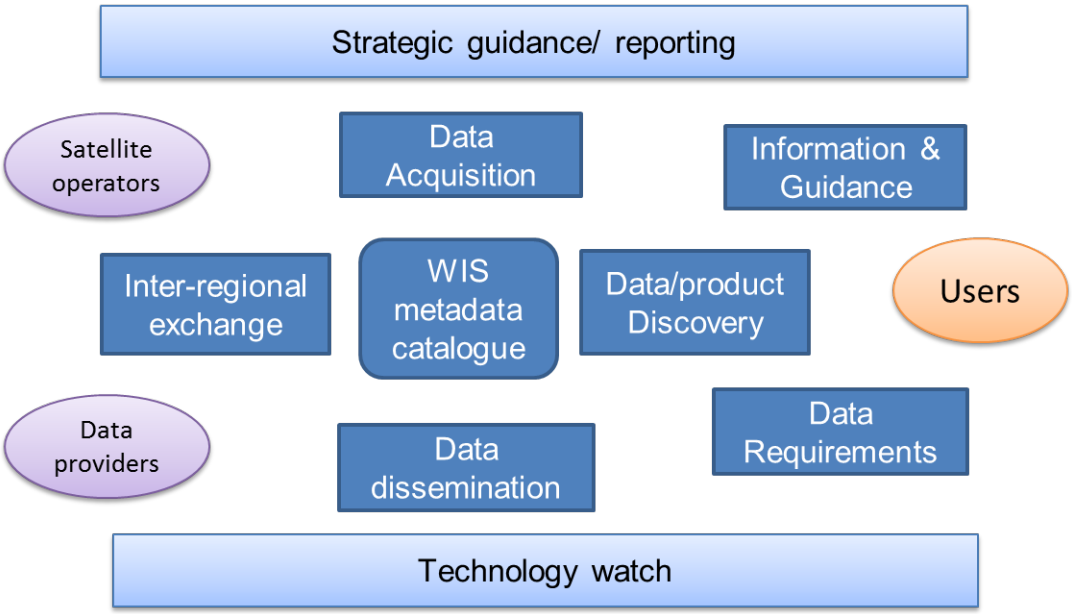


Figure 5: Functional elements to be addressed (rectangles) and implementing partners (ovals).

ANNEX VIII
Annex to paragraph 3.1.6 of the general summary

PROPOSED RESPONSIBILITY WITHIN THE COMMISSION FOR BASIC SYSTEMS FOR THE OVERSIGHT AND REVIEW OF THE OBSERVING SYSTEMS CAPABILITY ANALYSIS AND REVIEW TOOL

CBS Team	*Role*	*Reporting to*
ICT-IOS	Lead	ICG-WIGOS
IPET-WIFI	1) Overall coordination and leadership at the technical level 2) Regulatory Materials and metadata required in liaison with ICG-WIGOS and its dedicated Task Teams	ICT-IOS
IPET-OSDE	1) Functional requirements with regard to the tools required for the RRR process 2) Review content required for the RRR process including the observational requirements from application areas	IPET-WIFI
ET-SAT	Space-based observing systems capabilities (programmatic and technical updates)	IPET-WIFI
ET-SUP	Space-based observing systems capabilities (user assessments)	IPET-WIFI
ET-ABO	Aircraft-based observing systems capabilities	IPET-WIFI
ET-SBO	Surface-based observing systems capabilities	IPET-WIFI
ICTSW	Space Weather capabilities (surface- and space-based)	IPET-WIFI

ANNEX IX
Annex to paragraph 3.1.7 of the general summary

REVISED TERMS OF REFERENCE OF THE INTER-PROGRAMME EXPERT TEAM ON WIGOS FRAMEWORK IMPLEMENTATION MATTERS

The Inter-Programme Expert Team on WIGOS Framework Implementation Matters (IPET-WIFI) shall:

(a) Address integration aspects of WIGOS as defined in the WIGOS Framework Implementation Plan, based on guidance from ICG-WIGOS;

(b) Provide technical advice, guidance, practices and procedures for WIGOS Framework Implementation, in collaboration with CIMO; with priorities to be given to the GOS-related material in the:

  (i) WIGOS Regulatory Material (such as WIGOS Manual, GOS Manual and Guide), in collaboration with the relevant WMO Programmes and TCs;

  (ii) Standards for basic WIGOS metadata (e.g., those agreed for international exchange and for WIGOS Operational DB), including the access to WIGOS metadata;

  (iii) WIGOS Quality Management, including monitoring;

  (iv) WIGOS Information Resource in collaboration with other OPAG-IOS Expert Teams;

  (v) WIGOS standards and best practices;

  (vi) Capacity development, education and outreach strategy;

(c) The IPET-WIFI is envisaged to encompass three sub-groups (SGs), each to be activated as/when required:

  (i) Sub-group on Regulatory Material;

  (ii) Sub-group on Metadata;

  (iii) Sub-group on QM.

ANNEX X
Annex to paragraph 3.1.10 of the general summary

WMO INTEGRATED GLOBAL OBSERVING SYSTEM METADATA STANDARD

WIGOS Metadata Standard

ICG-WIGOS TT-WMD

CIMO: Brian Howe, Environment Canada, Canada (Chair)

CBS: Karl Monnik, Bureau of Meteorology, Australia

JCOMM: Joe Swaykos, NOAA National Data Buoy Center, United States

CCl: Manuel Bañón Garcia, Antonio Mestre, State Meteorological Agency (AEMET), Spain

CAeM: Stewart Taylor, Met Office, United Kingdom

Member: ZHAO Licheng, China Meteorological Administration, China

CHy: Tony Boston, Bureau of Meteorology, Australia

CAS: Jörg Klausen, Federal Office of Meteorology and Climatology MeteoSwiss, Switzerland

Associate Member: Tim Oakley (GCOS)

WMO Secretariat

Roger Atkinson, Steve Foreman, Luis Nunes

Draft Version 0.1.03

10 July 2014

Version Control

Version	Date	Who	What
0.0.0	2013-06-06	J. Klausen	Consolidate input received from Brian Howe after TT-WMD telecom-2
0.0	2013-06-06	J. Klausen	Same as v0.0.0 w/o track changes; new definition of 1-04, code list 1-05
0.0.1	2013-06-10	J. Klausen	Included content for category 4 (environment)
0.0.2	2013-06-30	S Taylor	Included content for category 10 (contact)
0.0.3	2013-07-01	T Boston	Edits to category 7 (station/platform)
0.0.4	2013-07-02	K Monnik	
0.0.5	2013-07-16	J. Klausen, B. Howe	Version after Telecon-3
0.0.6	2013-07-18	T. Boston	Edits to category 4 (environment), category 7 (station/platform); code tables 4-02; 7-03
0.0.7	2013-08-06	J. Klausen	After Telecon-4
0.0.8	2013-09- 0208-29	T. Boston, B. Howe	Edits to topography category 5 and platform/station model corresponding code table.
0.0.9	2013-09-03	J. Klausen	After Telecon-5
0.0.10	??	??	Intermediate version of uncertain origin
0.0.11	2013-10-3	J. Klausen	After Telecon-6, with expansions not discussed during telecom
0.0.12	2013-10-03	B. Howe	After Telecon-6 with changes accepted.
0.0.13	2013-10-24	B. Howe	After Telecon-7
0.0.13.ra	2013-10-31	R. Atkinson	Responses to a number of comments in 0.0.13
0.0.13.ra+km	2013-11-04	K. Monnik	General edits, additions to Cat 8, added examples to Cat 1, 5, 7.
0.0.14	2013-11-04	J. Klausen	After Telecon-8
0.0.14 km	2013-11-06	K. Monnik	Minor changes to 6.06, 8.03, 8.10, plus selected comments from Blair Trewin (AU)
0.0.15	2013-11-11	J. Klausen	After Telecon-9, and including feed-back from P. Pilon/ R. Atkinson
0.0.16			After Telecon-10
0.0.17	2013-12-19	J. Klausen	After Telecon-11
0.0.18	2014-02-06	J. Klausen, K Monnik	Response to Wiel Wauben, Bruce Forgan; version after Telecon-12, with further additions and edits, formatting
0.0.19			
0.0.20	2014-03-12 2014-03-18	B. Howe J. Klausen	After Telecon-15, accepted ICG-WIGOS MCO classifications and added two requested fields. Numerous other updates accepted. Comments by ET-SUP carried over.
0.0.21	2014-03-27	J. Klausen	Element 5-04 (Reporting interval (space)) explicitly listed; code table 5-05 included; element 5-11 (reference time) defined and explained; numbering in list of category 5 corrected; Figures 1 and 2 updated
0.0.22	2014-04-03	J. Klausen	After Telecon-16
0.0.23	2014-04-28	J. Klausen	After Telecon-17, several changes accepted, minor editing, fixed a few cross-references
0.1	2014-05-15	J. Klausen	Version after TT-WMD-2; dropped notion of “Core” in favour of a phased implementation; added element 8-00; dropped 4-04; moved element 8-05 to become 4-04; editorial improvements
0.1.01	2014-05-19	WIGOS PO	Editorial
0.1.02	2014-07-03	WIGOS PO	Review with comments and proposed changes
0.1.03	2014-07-10	TT-WMD	WebEx Sessions (03rd and 10th July 2014)

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I – Purpose and Scope of WIGOS Metadata

An important aspect of WIGOS (WMO Integrated Global Observing System) implementation is ensuring maximum usefulness of WIGOS observations. Observations without metadata are of very limited use: it is only when accompanied by adequate metadata (data describing the data) that the full potential of the observations can be utilized. Metadata of two complementary types are required. The first of these is **discovery metadata** – information that facilitates data discovery, access and retrieval. **These metadata are WIS (WMO Information System) metadata** and are specified and handled as part of WIS. The second type is **interpretation/description or observational metadata** – information that enables data values to be interpreted in context. **These latter metadata are WIGOS metadata** and are the subject of this standard, which provides a WIGOS standard for the interpretation metadata required for the effective utilization of observations from all WIGOS component observing systems by all users.

WIGOS metadata should describe the observed quantity, the conditions under which it was observed, how it was measured, and how the data has been processed, in order to provide data users with confidence that the use of the data is appropriate for their application. GCOS (Global Climate Observing System) Climate Monitoring Principle #3 describes the relevance of metadata as:

> *"The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e., metadata) should be documented and treated with the same care as the data themselves."*

WIGOS observations consist of an exceedingly wide range of data from the manual observations to complex combinations of satellite hyper-spectral frequency bands, measured in situ or remotely, from single dimension to multiple dimensions, and those involving processing. A comprehensive metadata standard to cover all types of observations is by nature complex to define. A user should be able to use the WIGOS metadata to identify the conditions under which the observation (or measurement) was made, and any aspects which may affect its use or understanding, i.e. to determine whether the observations are fit for the purpose.

II – WIGOS Metadata Categories

Ten categories of WIGOS metadata have been identified. These are listed in Table 1 below. They define the WIGOS metadata standard, each category consisting of one or more metadata elements. All of the categories listed are considered to be important for the documentation and interpretation of observations made, and even to be made in the distant future. Hence, the standard currently declares many elements that are clearly not needed for applications focusing on more immediate use of observations. For these applications, such as numerical weather prediction, aeronautical or other transport sector applications, advisories, etc., profiles of the standard would have to be developed. The categories are in no particular order but reflect the need to specify the observed quantity; to answer why, where and how the observation was made; how the raw data were processed; and what the quality of the observation is.

A schematic composition of all categories, containing the individual elements is shown in

Figure 1. Note that some of these elements will most likely be implemented using several individual entities (e.g., geospatial location will consist of the atomic elements latitude, longitude, elevation or a set of polar coordinates.). Chapter VII contains a set of tables detailing all the elements, including definition, notes/examples, code tables and obligations/implementation phase.

Table 1. WIGOS Metadata Categories

#	Category	Description
1	observed quantity	Specifies the basic characteristics of the observed quantity and the resulting datasets.
2	purpose of observation	Specifies the main application area(s) of the observation and the observing programme(s) the observation is affiliated to.
3	data quality	Specifies the data quality and traceability of the observation.
4	environment	Describes the geographical environment within which the observation is made. It also provides an unstructured element for additional meta-information that is considered relevant for adequate use of the data and that is not captured anywhere else in this standard.
5	data processing and reporting	Specifies how raw data are transferred into the reported physical quantities and reported to the users.
6	sampling and analysis	Specifies how sampling and/or analysis are used to derive the reported observation or how a specimen was collected.
7	station/platform	Specifies the environmental monitoring facility, including fixed station, moving equipment or remote sensing platform, at which the observation was made.
8	method of observation	Specifies the method of observation and describes characteristics of the instrument(s) used to make the observation. If multiple instruments used to generate the observation, then this category should be repeated.
9	ownership and data policy	Specifies who is responsible for the observation and owns it.
10	contact	Specifies where information about the observation or dataset can be obtained.

For example, an observation/dataset may have the following metadata categories associated with it:

- One or several purpose(s) of observation (e.g. upper-air observations and surface synoptic observations)
- Data processing procedures associated with the instruments
- Instruments which have been used to make the observation
- A station/platform to which the instrument(s) belong(s)
- Ownership and data policy restriction
- Contact

An instrument may observe/measure one or more quantities. For example:

- a resistance temperature device can report temperature;
- a humidity probe can report temperature and humidity;
- a sonic anemometer can report wind speed, wind direction and air temperature.

An instrument may be associated with:

- sampling and analysis (e.g. 10 Hz samples of air temperature);
- data processing (e.g. ceilometer reporting of 10 min statistics of cloud height following processing through sky condition algorithm).

An observed quantity may be influenced or characterized by the environment, for example:

- wind speed (observed quantity) on top of a hill (environment);
- river yield (observed quantity) characterized by the upstream catchment and land use.

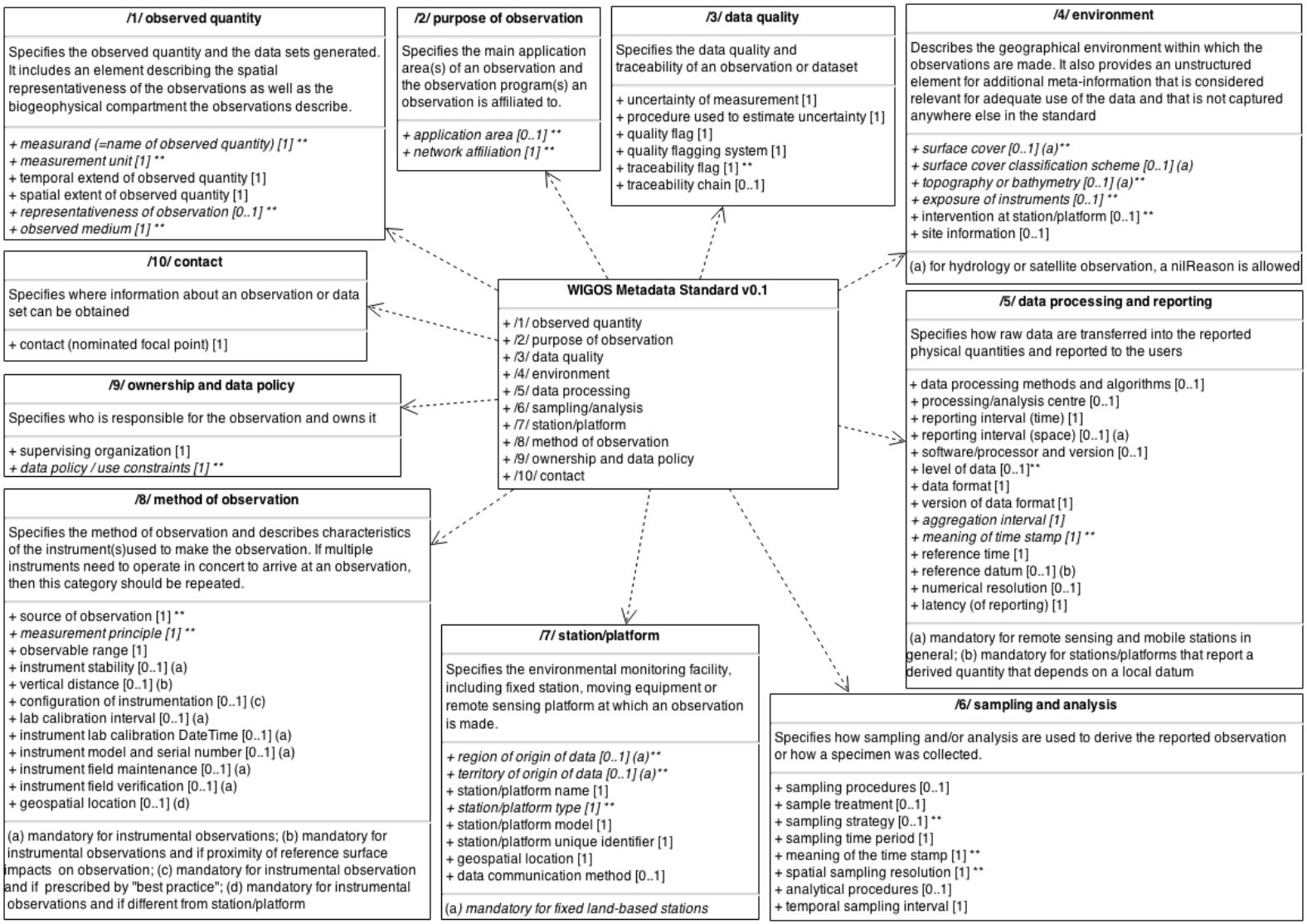


Figure 1. UML diagram specifying the WIGOS Metadata Standard (: code tables expected; [0..1*]: optional or conditional elements. Conditional elements become mandatory if a given condition is met. Conditions are referenced in parentheses. Optional elements may be declared mandatory as part of profiling the standard for specific application areas; [1..*]: mandatory elements. These elements must be reported, and if no value is available, a nilReason must be reported, which indicates that the metadata is "unknown", or "not available")**

III – A Note on Space and Time

It is important to understand that WIGOS metadata are intended to describe an observation or a dataset, i.e. one or several observations, including the where, when, how, and even why the observations were made. As a consequence, references to space and time are made in several places throughout the standard.

Figure 2 illustrates the concepts and terms used to describe the **temporal aspects** of an observation or dataset, including sampling strategy, analysis, data processing and reporting.

The concepts and terms used to describe **spatial aspects** (i.e., geospatial location) of observations are even more complex (cf. Fig. 3). For example, for ground-based in-situ observations, the spatial extent of the observation coincides with the geospatial location of the sensor, which in most cases will be time-invariant and is normally close to the geospatial location of the station/platform where the observation was made. For a satellite-based lidar system, the situation is quite different. Depending on the granularity of metadata desired, the spatial extent of the individual observation may be an individual pixel in space, the straight line probed during an individual laser pulse, or perhaps an entire swath. In any case, the spatial extent of the observation will not coincide with the location of the sensor. The WIGOS metadata standard therefore needs to take into account such quantities as

1. the spatial extent of the observed quantity (e.g. atmospheric column above a Dobson Spectrophotometer) (cf. 1-04)
2. the geospatial location of the station/platform (e.g. radar transmitter/receiver or aircraft position/route) (cf. 7-07)
3. the geospatial location of the instrument (e.g. the anemometer is adjacent to a runway) (cf. 8-05 Vertical Distance and 8–12 geospatial location)
4. the spatial representativeness of the observation (cf. 1-05)

All these are expressed in terms of geospatial location, specifying either a zero-dimensional geographic extent (a point), a one-dimensional geographic extent (a line, either straight or curved), a two-dimensional geographic extent (a plane or other surface), or a three-dimensional geographic extent (a volume).

A station/platform can be:

1. collocated with the observed quantity as for in situ surface observing station (e.g. AWS)
2. collocated with the instrument but remote to the observed quantity (e.g. Radar)
3. emote from where the instrument may transmit data to the station (e.g. Airport surface station where instruments are located across the airport, or a balloon atmosphere profiling station)
4. in motion and travelling through the observed medium (e.g. Aircraft AMDAR equipped aircraft)
5. in motion and remote to the observed medium (e.g. satellite platform)

An instrument can be:

1. collocated with the observed quantity (e.g. surface temperature sensor)
2. remote to the observed quantity (e.g. radar transmitter/receiver)
3. in motion but located in the observed medium (e.g. radiosonde)
4. in motion and remote from the observed quantity (e.g. satellite based radiometer)
5. located within a standardized enclosure (e.g. a temperature sensor within a Stevenson screen)

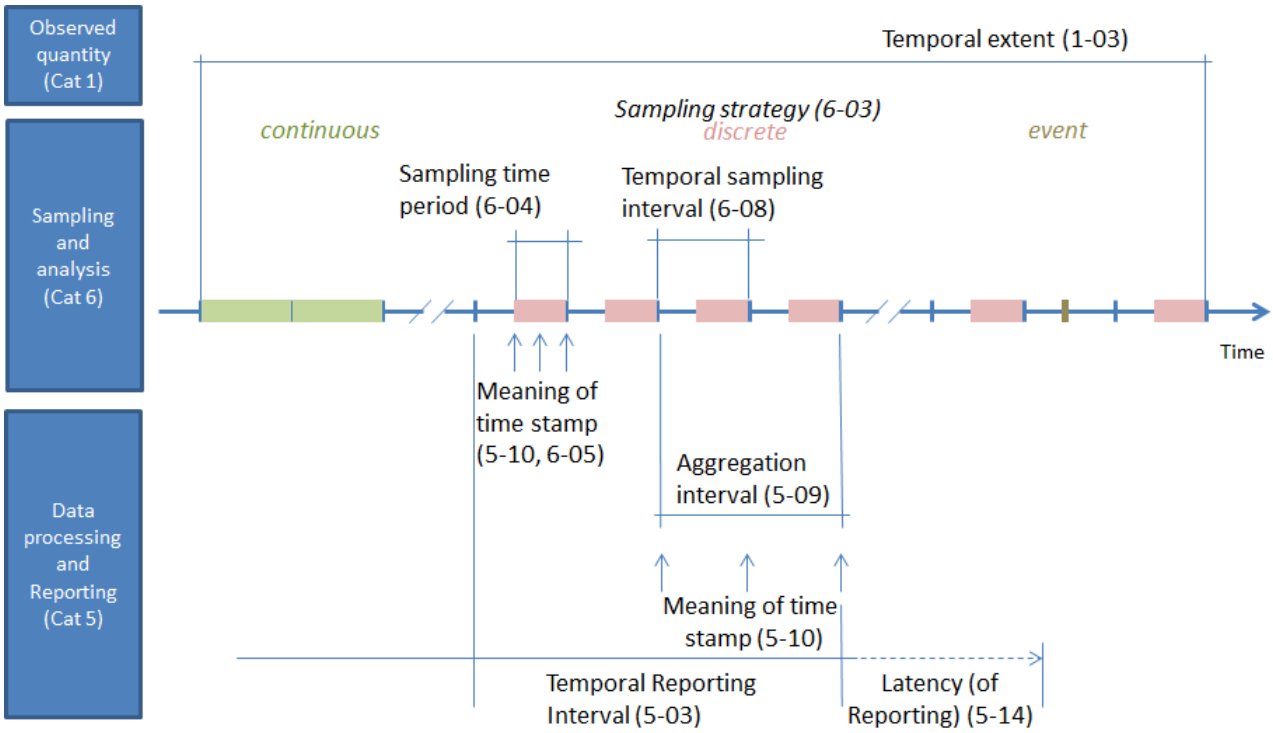


Figure 2. Graphical representation of temporal elements referenced in WIGOS Metadata categories – see Section VII for definitions and notes/examples

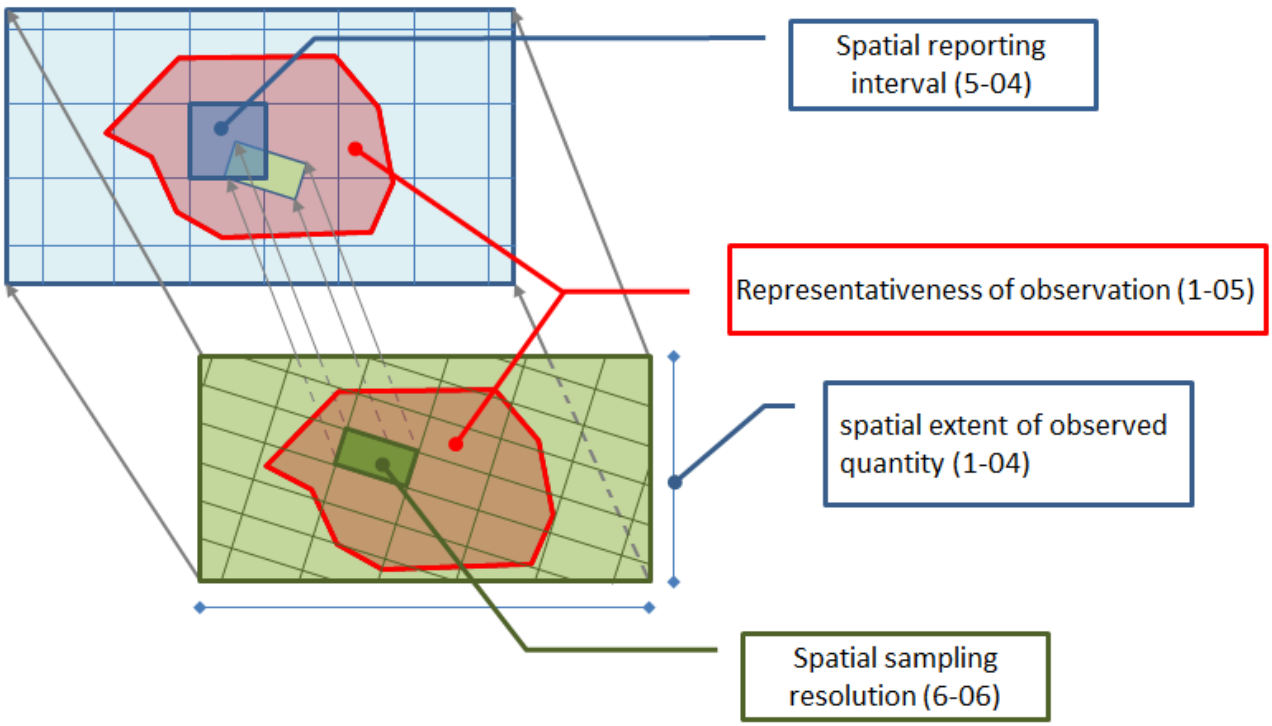


Figure 3. Graphical representation of spatial elements referenced in WIGOS Metadata categories

IV – Reporting Obligations for WIGOS Metadata

According with the International Organization for Standardization (ISO), the elements are classified as either mandatory (M), conditional (C), or optional (O).

Mandatory metadata elements shall always be made available. The content of the corresponding fields shall never be empty, either the metadata “value” or the reason for no-value, shall be made available.

Most of the elements in this standard are considered **mandatory** in view of enabling adequate future use of observations by all WMO Application Areas. Metadata providers are expected to report mandatory metadata elements, and a formal validation of a metadata record will fail if mandatory elements are not reported. If Members cannot provide all the Mandatory elements the reason for that shall be reported as “not applicable” or “unknown” or “not available”. The motivation for this is that knowledge of the reason why a mandatory metadata element is not available provides more information than not reporting a mandatory element at all. In the tables below, these cases are indicated with $M^{\#}$.

Conditional metadata elements shall be made available when the specified condition or conditions are met, in which case the content of the corresponding fields shall never be empty, either the metadata “value” or the reason for no-value, shall be made available. . For example, the element “Reporting interval (space)” is classified as conditional, because it only applies to remote sensing observations and mobile platforms. Therefore, the elements in this category should be considered mandatory for remote sensing and mobile observing systems but not so for e.g., surface land stations.

Optional metadata elements should also be made available. They provide useful information that can help to better understand an observation. In this version of the standard, very few elements are considered optional. Optional elements are likely to be important for a particular community, but less so for others.

V – Implementation and Use of Standard

This document is a semantic standard, not an implementation guideline. A semantic standard specifies the elements that exist and that can be recorded and reported. It does not specify how the information shall be encoded or exchanged. However, the following are likely scenarios and important aspects that may help the reader appreciate what lies ahead.

1. The most likely implementation will be in XML, in line with the specifications for WIS metadata and common interoperability standards. Regardless of the final implementation, the full metadata record describing a dataset can be envisioned as a tree with the category as branches off the stem, and the individual elements as leaves on these branches. Some branches may occur more than once, e.g., a dataset may have been generated using more than one instrument at once, in which case two branches for 'instrument' may be required.

2. Not all of the elements specified in this document need to be updated at the same frequency. Some elements, such as position of a land-based station are more or less time-invariant, while others, such as a specific sensor, may change regularly every year. Still other elements, such as environment, may change gradually or rarely, but perhaps abruptly. Finally, elements restricting the application of an observation, e.g., to road condition forecasting, may have to be transmitted with every observation. The implementation of the WIGOS metadata needs to be able to deal with this.

3. Not all applications of observations require the full suite of metadata as specified in this standard at any given time. The amount of metadata that needs to be provided to be able to make adequate use of an observation, for example for the purpose of issuing a heavy precipitation warning, is much less than for the adequate use of even the same observation for a climatological analysis. On the other hand, the metadata needed for near-real-time applications also need to be provided in near-real-time. This is important to realize, as it makes the task of providing WIGOS metadata much more tractable. The implementation of WIGOS metadata needs to be able to cope with vastly different update intervals, and incremental submission of additional metadata to allow the creation of 'complete' metadata records.

4. Users will want to obtain and filter datasets according to certain criteria/properties as described within each WIGOS metadata record. This functionality requires either a central repository for WIGOS metadata or full interoperability of the archives collecting WIGOS metadata.

How, then can these requirements be met? In the case where observations are clearly only used for some near-real-time application and there is clearly no long-term use or re-analysis application to be expected, a profile of the WIGOS metadata standard may be specified that declares a specific subset of metadata elements as mandatory. This is depicted schematically in Figure 4.

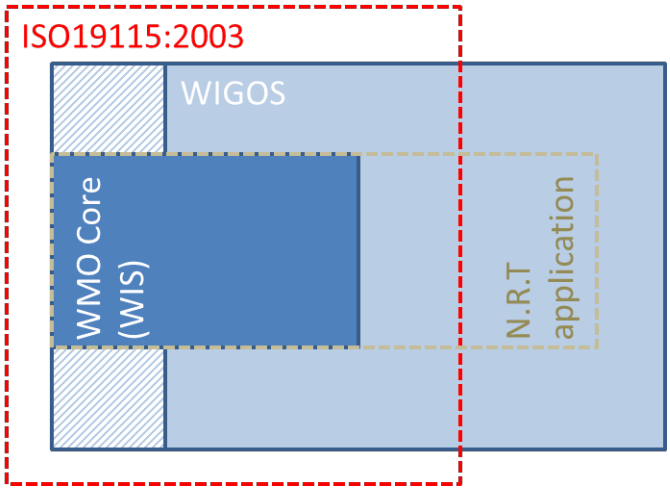


Figure 4. Schematic of the relationship of WIS and WIGOS metadata and the scope of the ISO19115 standard. The WMO Core is a profile of ISO19115. WIGOS metadata exceed the scope of the ISO19115 standard. A possible profile (subset) of WIGOS metadata elements for some specific near-real-time application is also shown.

Importantly, all WIGOS metadata elements (or group of elements) will have to be time-stamped with the time of validity and associated to a unique identifier for a dataset during transmission and for archiving. Using this approach, increments of a 'full' WIGOS metadata record can be transmitted anytime changes occur and updates are deemed necessary. At the archive, the increments can be added to the existing metadata record for that dataset, in time establishing the full history of a particular observation.

VI – Adoption through a Phased Approach

Making available WIGOS metadata will generate substantial benefits for Members, but developing the capacity to make available these metadata also requires a substantial effort on the part of (meta)data providers. To help Members comply with obligations, guidance material will be developed and provided.

Moreover, obligations will be enforced in phases, in order to allow Members sufficient time to develop the capacity to comply. Balancing the effort required to generate and make available the metadata elements, and the need to have this information to make adequate use of observations, implementation will proceed through three phases as shown in Table 2. Importantly, elements required by the end of **Phase I** are either listed as mandatory elements in WMO-No. 9, Vol. A or are of critical importance for the Observing Systems Capability Analysis and Review (OSCAR) tool of the WIR (WIGOS Information Resource), and are considered of benefit for all application areas. **Phase II** adds elements recognized to be more challenging for Members, but the knowledge of which is still of rather immediate need for the adequate use of observations, in particular for assessing quality of observations. **Phase III** adds the remaining elements specified in this version of the standard.

Elements emerging as being important for specific application areas or observing programs will be added to the standard as it evolves.

Category	Phase I	Phase II	Phase III
	2016	2017–2018	2019–2020
1. Observed Quantity	**1-01 Name of observed quantity – measurand (M)**	1-05 Representativeness of observation (O)	
	1-02 Measurement unit (M)		
	1-03 Temporal extent of observed quantity (M)		
	1-04 Spatial extent of observed quantity (M)		
	1-06 Observed medium (M)		
2. Purpose of Observation	2-01 Application area(s) (O)		
	2-02 Network affiliation (M)		
3. Data Quality		**3-01 Uncertainty of measurement (M)**	
		3-02 Procedure used to estimate uncertainty (M)	
		3-03 Quality flag (M)	
		3-04 Quality flagging system (M)	
		3-05 Traceability flag (M)	
		3-06 Traceability chain (C)	
4. Environment		*4-04 Exposure of instrument (C)*	*4-01 Surface cover (C)*
		4-05 Intervention at Station/platform (O)	*4-02 Surface Cover classification scheme (C)*
		4-06 Site information (O)	*4-03 Topography or Bathymetry (C)*
5. Data Processing and Reporting	**5-03 Reporting interval (time) (M)**	5-02 Processing/analysis centre (O)	5-01 Data processing methods and algorithms (O)
	5-04 Reporting interval (space) (C)	5-06 Level of data (O)	5-05 Software/processor and version (O)
	5-12 Reference datum (C)	**5-09 Aggregation interval (M)**	**5-07 Data format (M)**
		5-10 Meaning of time stamp (M)	**5-08 Version of data format (M)**
		5-11 Reference time (M)	5-13 Numerical resolution (O)
			5-14 Latency (of reporting) (M)

Category	Phase I	Phase II	Phase III
	2016	2017–2018	2019–2020
6. Sampling and Analysis	6-03 Sampling strategy (O)	**6-06 Spatial sampling resolution (M)**	6-01 Sampling procedures (O)
			6-02 Sample treatment (O)
			6-04 Sampling time period (M)
			6-05 Meaning of the time stamp (M)
			6-07 Analytical procedures (O)
			6-08 Temporal sampling interval (M)
7. Station/Platform	*7-01 Region of origin of data (C)*	**7-04 Station/platform type (M)**	**7-05 Station/platform model (M)**
	7-02 Territory of origin of data (C)	7-08 Data communication method (O)	
	7-03 Station/platform name (M)		
	7-06 Station/platform unique identifier (M)		
	7-07 Geospatial location (M)		
8. Method of Observation	**8-01 Source of observation (M)**	*8-12 Geospatial location (C)*	*8-06 Configuration of instrumentation (C)*
	8-02 Measurement principle (M)		*8-07 Lab calibration interval (C)*
	8-03 Observable range (M)		*8-08 Instrument lab calibration date and time (C)*
	8-04 Instrument stability (C)		*8-09 Instrument model and serial number (C)*
	8-05 Vertical distance (C)		*8-10 Instrument field maintenance (C)*
			8-11 Instrument field verification (C)
9. Ownership and Data Policy	**9-02 Data policy/use constraints (M)**	**9-01 Supervising organization (M)**	
10. Contact			**10-01 Contact (Nominated Focal Point) (M)**

Table 2. List of elements specified in the WIGOS Metadata Standard and the phases for implementation by Members.

VII – List of tables for categories, with details about each metadata elements

Category 1: Observed Quantity

This category groups elements that specify the observed quantity and the datasets generated. It includes an element describing the spatial representativeness of the observations as well as the biogeophysical compartment the observations describe.

Id	Name	Definition	Note or Example	Code Table	ItemMCO[1]
1-01	Name of observed quantity – **measurand**	Quantity intended to be measured or observed or derived	*[JCGM 200:2012, 2.3] NOTE 1:* The specification of a measurand requires knowledge of the kind of quantity, description of the state of the phenomenon, body, or substance carrying the quantity, including any relevant component, and the chemical entities involved. *[*JCGM 200:2012*, 2.3] NOTE 2:* In the second edition of the VIM and in IEC 60050-300:2001, the measurand is defined as the "particular quantity subject to measurement". *[*JCGM 200:2012*, 2.3] NOTE 3:* The measurement, including the measuring system and the conditions under which the measurement is carried out, might change the phenomenon, body, or substance such that the quantity being measured may differ from the measurand as defined. In this case, adequate correction is necessary. *[*JCGM 200:2012*, 2.3] NOTE 4:* In chemistry, "analyte", or the name of a substance or compound, are terms sometimes used for 'measurand'. This usage is erroneous because these terms do not refer to quantities. *[ISO19156] NOTE 5:* In conventional measurement theory the term "measurement" is used. However, a distinction between measurement and category-observation has been adopted in more recent work so the term "observation" is used for the general concept. "Measurement" may be reserved for cases where the result is a numeric quantity. *EXAMPLE:* In hydrology, this would typically be stage or discharge.	1-01	M* (Phase 1)

1 An asterisk (*) denotes the element is required for the WIGOS Rolling Review of Requirements (RRR) process. A hash sign (#) denotes that it is acceptable to record a "mandatory" element with a value of nilReason (that indicates that the metadata is either "unknown", or "not applicable", or "not available").

Id	Name	Definition	Note or Example	Code Table	ItemMCO[1]
1-02	**Measurement unit**	Real scalar quantity, defined and adopted by convention, with which any other quantity of the same kind can be compared to express the ratio of the two quantities as a number [VIM3, 1.9]	*[*JCGM 200:2012*, 1.9] NOTE 1.* Measurement units are designated by conventionally assigned names and symbols. *[*JCGM 200:2012*, 1.9] NOTE 2* Measurement units of quantities of the same **quantity dimension** may be designated by the same name and symbol even when the quantities are not of the same kind. For example, joule per kelvin and J/K are respectively the name and symbol of both a measurement unit of heat capacity and a measurement unit of entropy, which are generally not considered to be quantities of the same kind. However, in some cases special measurement unit names are restricted to be used with quantities of a specific kind only. For example, the measurement unit 'second to the power minus one' (1/s) is called hertz (Hz) when used for frequencies and becquerel (Bq) when used for activities of radionuclides. *[*JCGM 200:2012*, 1.9] NOTE 3* Measurement units of **quantities of dimension one** are numbers. In some cases these measurement units are given special names, e.g. radian, steradian, and decibel, or are expressed by quotients such as millimole per mole equal to 10^{-3} and microgram per kilogram equal to 10^{-9}. *[*JCGM 200:2012*, 1.9] NOTE 4* For a given quantity, the short term "unit" is often combined with the quantity name, such as "mass unit" or "unit of mass". *EXAMPLE* In hydrology, this would typically be m for stage or m^3/s for discharge.	1-02	M* (Phase 1)
1-03	**Temporal extent** of observed quantity	Time period covered by a series of observations inclusive of the specified date-time indications (measurement history).	*NOTE 1*: The Temporal Extent is defined through the begin and end dates of observations. *NOTE 2*: If the data are still being added to, omit the End date (but specify a Begin date). *NOTE 3*: If there are gaps in the data collection (e.g. 1950-1955 then collection resumes 1960-present) then the first date recorded should be the earliest date and the last the most recent, ignoring the gap.		M* (Phase 1)

Id	Name	Definition	Note or Example	Code Table	ItemMCO[1]
			EXAMPLES: Surface temperature at the station Säntis has been observed since 1 September 1882. The CO2 record at Mauna Loa extends from 1958 to today. Continuous, 1-hourly aggregates are available from the World Data Centre for Greenhouse Gases for the period 1974-01-01 to 2011-12-31		
1-04	**Spatial extent** of observed quantity	Geographic location specifying the spatial extent of the observed quantity	*NOTE 1*: The spatial extent of an observed quantity can be a zero-, one-, two-, or three-dimensional feature and will be expressed in terms of a series of geospatial locations describing a geometric shape. *NOTE 2*: A zero-dimensional geospatial location of an observation implies either an in-situ (point) observation or, by convention, a column-averaged quantity above the specified geospatial location in nadir. One-dimensional geospatial location of an observation implies a distribution / profile of a quantity along a trajectory (e.g., a straight line from the ground up with a given zenith angle). A two-dimensional geospatial location of an observation implies an area or hyper-surface (e.g., a radar image, or a satellite pixel of a property near the surface). A three-dimensional geospatial location of an observation implies a volume-averaged quantity (e.g., a radar pixel in 3D-space). *EXAMPLES:* i) Air temperature at a surface observing site: Sydney Airport NSW: Lat. –33.9465 N; Lon. 151.1731 E, Alt: 6.0 m above msl. ii) The projected area or volume of the cone around a particular weather radar with a maximum range of 370 km (radar reflectivity) and 150 km (Doppler); to be expressed as a geometric shape. iii) 3-dimensional grid of radar pixels iv) Infrared and visible imagery by meteorological satellite (sunsynchronous): VIRR (FY-3), Global coverage twice/day (IR) or once/day (VIS) v) River discharge by gauge: size and geometric shape of a river Catchment.		M* (Phase 1)

Id	Name	Definition	Note or Example	Code Table	ItemMCO[1]
1-05	Representativeness of the observation	Spatial extent of the region around the observation for which an observed quantity value is representative	*NOTE 1*: The representativeness of an observation is the degree to which it describes the value of the variable needed for a specific purpose. Therefore, it is not a fixed quality of any observation, but results from joint appraisal of instrumentation, measurement interval and exposure against the requirements of some particular application (WMO-No. 8, 2008). Representativeness of an observed value describes the concept that the result of an observation made at a given geospatial location would be compatible with the result of other observations of the same quantity at other geospatial locations. In statistics, the term describes the notion that a sample of a population allows an adequate description of the whole population. Assessing representativeness can only be accomplished in the context of the question the data [or observations] are supposed to address. In the simplest terms, if the data [or observations] can answer the question, it is representative (Ramsey and Hewitt, 2005). The representativeness of an environmental observation depends on the spatio-temporal dynamics of the observed quantity (Henne et al., 2010). Representativeness of an observation can sometimes be specified quantitatively, in most cases qualitatively, based on experience or heuristic arguments.	1-05	O (Phase 2)
1-06	Observed medium	Specification of the medium or matrix of which the observation was made.	*NOTE:* Relevant media or matrices include air, aerosol, water, ocean, soil, cloud water, aerosol particulate phase, troposphere, upper troposphere/lower stratosphere, etc.	1-06	M (Phase 1)

<u>Code list definitions</u>

Code table: 1-01

Code table title: Name of observed quantity – measurand

[Code table under development]

Code table: 1-02

Note: Make reference to http://www.bipm.org/en/si/si_brochure/, mention units such as °C, hPa

Code table: 1-05
Code table title: Representativeness [WMO-No. 8, 2008]

#	Name	Definition
1-05-0	Nil reason	None of the codes in the table is applicable in the context of the observed quantity or unknown, or not available information
1-05-1	microscale	An area or volume less than 100 m horizontal extent (for example, evaporation)
1-05-2	toposcale, local scale	An area or volume of 100 m to 3 km horizontal extent (for example, air pollution, tornadoes)
1-05-3	mesoscale	An area or volume of 33 km to 100 km horizontal extent (for example, thunderstorms, sea and mountain breezes)
1-05-4	large scale	An area or volume100 km to 3000 km horizontal extent (for example, fronts, various cyclones, cloud clusters)
1-05-5	planetary scale	An area or volume of more than 3000 km horizontal extent (for example, long upper tropospheric waves)
1-05-6	drainage area	An area (also known as ‘catchment’) having a common outlet for its surface runoff, in km^2

Code table: 1-06
Code table title: Observed medium [Code table under development]

#	Name	Definition
1-06-0	air	Mixture of gases which compose the Earth’s atmosphere. (source: WMO No.182)
1-06-1	water	Liquid phase of a chemical compound consisting of approximately two parts by weight of hydrogen and 16 parts by weight of oxygen. In nature it contains small amounts of heavy water, gases and solids (mainly salts) in solution (International Glossary of Hydrology).
1-06-2	ocean surface	The top boundary of the ocean, the interface between ocean and atmosphere
1-06-3	land surface	The top boundary of the land mass, the interface between land and atmosphere
1-06-4	soil	mixture of minerals, organic matter, gases, liquids and a myriad of micro- and macro- organisms that can support plant life
1-06-5	aerosol	colloid of fine solid particles or liquid droplets, in air or another gas
1-06-6	aerosol particulate phase	The solid part of an aerosol
1-06-7	wet precipitation	The liquid phase of precipitation (“rain”, “drizzle”, …)
	solid precipitation	The solid phase of precipitation (“snow”, “hail”, …)
1-06-8	atmospheric boundary layer	
1-06-9	lake	A water body confined by land masses
	River	
1-06-10	cloud	
1-06-11	lower troposphere	
1-06-12	upper troposphere / lower stratosphere	
1-06-12	upper stratosphere	
1-06-13	sea water	
	inland water	
1-06-14	space	
1-06-15	ocean sub-surface	
1-06-16	cryosphere	
1-06-17	ocean floor	
	ocean basin	
1-06-xx	…	

Category 2: Purpose of Observation

This category specifies the main application area(s) of an observation and the observation programme(s) an observation is affiliated to.

Id	Name	Definition	Note or Example	Code Table	ItemMCO
2-01	Application area(s)	Context within, or intended application(s) for which the observation is primarily made or which has/have the most stringent requirements.	*NOTE:* Many observations serve more than one purpose, meeting the requirements of various applications areas. In such cases, the application area for which the station was originally established should be listed first.	2-01	O* (Phase 1)
2-02	Network affiliation	For a station, the affiliation enumerates the regional or global network(s) that the station/platform is associated with.	*EXAMPLES:* GUAN, AMDAR, GAW, RBSN, WHOS, etc. (full names to be referenced in code table)	2-02	M (Phase 1)

Code list definitions

Code table: 2-01
Code table title: Application area [Code table under development]

#	Name	Definition
2-01-1	Global numerical weather prediction (GNWP)	Source: http://www.wmo.int/pages/prog/www/wigos/wir/application-areas.html
2-01-2	High-resolution numerical weather prediction (HRNWP)	Ibid
2-01-3	Nowcasting and very short range forecasting (NVSRF)	Ibid
2-01-4	Seasonal and inter-annual forecasting (SIAF)	Ibid
2-01-5	Aeronautical meteorology	Ibid
2-01-6	Atmospheric chemistry	Ibid
2-01-7	Ocean applications	Ibid
2-01-8	Agricultural meteorology	Ibid
2-01-9	Hydrology	Ibid
2-01-10	Climate monitoring (as undertaken through the Global Climate Observing System, GCOS)	Ibid
2-01-11	Climate applications	Ibid
2-01-12	Space weather	Ibid
2-01-13	Cryosphere applications	Source: EGOS-IP
2-01-14	Energy sector	
2-01-15	Transportation sector	
2-01-16	Health sector	
2-01-17	Terrestrial ecology	

Code table: 2-02
Code table title: Network affiliation [Code table under development]

#	Name	Definition
2-02-1	RBON	Regional Basic Observing Network
	GSN	GCOS (Global Climate Observing System) Surface Network
2-02-2	GAW	Global Atmosphere Watch
2-02-2	GUAN	GCOS upper air network
2-02-3	AMDAR	…
	National network…	
…	… Others …	…

Category 3: Data Quality

This category specifies the data quality and traceability of an observation or dataset.

Id	Name	Definition	Note or Example	Code Table	ItemMCO
3-01	Uncertainty of measurement	Parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand [JCGM 100:2008]	*NOTE 1:* In principle, an uncertainty statement needs to be reported for each observation, as it can change from observation to observation. If the uncertainty of observations remain virtually constant over time, it is sufficient to report the uncertainty at the beginning of the period and then again when substantial changes of the uncertainty occur. The actual uncertainty statements should be reported with the observations. *NOTE 2:* Complex observations such as gridded satellite imagery may contain large error covariance matrices that are not useful for the purpose of this standard. Such information must be kept with the data, and it is sufficient to report an aggregate (e.g., mean or median) uncertainty in the metadata. *NOTE 3:* Uncertainty may be expressed, for example, as a standard deviation (or a given multiple of it), or the half-width of an interval having a stated level of confidence. *NOTE 4:* Uncertainty of measurement comprises, in general, many components. Some of these components may be evaluated from the statistical distribution of the results of series of measurements and can be characterized by experimental standard deviations. The other components, which also can be characterized by standard deviations, are evaluated from assumed probability distributions based on experience or other information. *NOTE 5:* It is understood that the result of the measurement is the best estimate of the value of the measurand, and that all components of uncertainty, including those arising from systematic effects, such as components associated with corrections and reference standards, contribute to the dispersion. *EXAMPLE:* A thermometer reading may yield a value of 13.7 deg C. An assessment of the quality of that observation may indicate that it has an expanded uncertainty of +/– 0.3 deg C (k=2), where k=2 is a coverage factor corresponding approximately to a confidence interval of 95%.		M*# (Phase 2)
3-02	Procedure used to estimate uncertainty	A reference or link pointing to a document describing the procedures/algorithms used to derive the uncertainty statement	Uncertainty is a well-defined term, and guidance material exists to assist in the assessment of the uncertainty of observations and a formulation of adequate uncertainty statements. The authoritative source is the “Guide for the Expression of Uncertainty in Measurement” (JCGM 100:2008).		

Id	Name	Definition	Note or Example	Code Table	ItemMCO
3-03	Quality flag	An ordered list of qualifiers indicating the result of a quality control process applied to the observation	*NOTE:* BUFR code table series 0-33 contains data quality flags/definitions. *EXAMPLE*: BUFR Code Table 0 33 020 contains the following elements: 0 Good 1 Inconsistent 2 Doubtful 3 Wrong 4 Not checked 5 Has been changed 6 Estimated 7 Missing value	3-03	M# (Phase 2)
3-04	Quality flagging system	System used to flag the quality of the observation	*NOTE 1:* At present, there is no single, globally accepted flagging system. The purpose of this element is to make reference to the flagging system used. This reference should either be a URL to a document explaining the meaning of the quality flag, or a link to a code table where this information can be found. *NOTE 2*: The use of the BUFR quality codes listed above is recommended (WMO, 2013)		
3-05	Traceability flag	Ability to define traceability to a standard		3-05	M*# (Phase 2)
3-06	Traceability chain	Sequence of measurement standards and calibrations that is used to relate a measurement result to a reference [VIM 3 2.4.2]	*[VIM 3, 2.4.2] NOTE 1:* A metrological traceability chain is defined through a calibration hierarchy; *[VIM 3, 2.4.2] NOTE 2:* A metrological traceability chain is used to establish metrological traceability of a measurement result. *[VIM 3, 2.4.2] NOTE 3:* A comparison between two measurement standards may be viewed as a calibration if the comparison is used to check and, if necessary, correct the **quantity value** and **measurement uncertainty** attributed to one of the measurement standards		C (Phase 2)

Condition for 3-06

Report if 3-05 {is either 1 or 2}

Code table: 3-05

Code table title: Traceability flag

#	Name	Definition
3-05-0	Unknown	Traceability not known
3-05-1	Traceable	Traceable to an international standard
3-05-2	Not traceable	Not traceable to an international standard

Category 4: Environment

This category describes the geographical environment within which the observations are made. It also provides an unstructured element for additional meta-information that is considered relevant for adequate use of the observations and that is not captured anywhere else in the standard.

Id	Name	Definition	Note or Example	Code table	ItemMCO
4-01	Surface cover	The observed (bio)physical cover on the earth's surface (DiGregorio, 2005, FAO) in the vicinity of the measurand	*NOTE 1:* Surface cover or land cover is distinct from land use despite the two terms often being used interchangeably. Land use is a description of how people utilize the land and socio-economic activity – urban and agricultural land uses are two of the most commonly known land use classes. At any one point or place, there may be multiple and alternate land uses, the specification of which may have a political dimension (Wikipedia, 2013). *NOTE 2:* There are various classification methods for 'land cover'. The MODIS product MCD12Q1 provides 5 different classifications on 500 m resolution grid (https://lpdaac.usgs.gov/products/modis_products_table/mcd12q1). These include the IGBP, UMD, LAI/fPAR, NPP and PFT classifications. *NOTE 3:* An alternative approach is the 'Land Cover Classification System' (LCCS) adopted by the Food and Agriculture Organization of the United Nations. Translation of other systems to LCCS has been explored by Herold et al. (2009). Eight major land cover types are identified during the first, dichotomous classification phase. These are refined in a subsequent so-called Modular-Hierarchical Phase, in which land cover classes are created by the combination of sets of pre-defined classifiers. These classifiers are tailored to each of the eight major land cover types. This process can be supported by software (http://www.glcn.org/sof_7_en.jsp) or manually using a field log sheet (http://commons.wikimedia.org/wiki/File:LCCS_field_protokoll.png)	4-01	C (Phase 3)
4-02	Surface cover classification scheme	Name and reference or link to document describing the classification scheme	IGBP, UMD, LAI/fPAR, NPPand PFT, LCCS (recommended implementation as a URI pointing to the code table)	4-02	C (Phase 3)

Id	Name	Definition	Note or Example	Code table	ItemMCO
4-03	Topography or bathymetry	The shape or configuration of a geographical feature, represented on a map by contour lines, hypsometric tints, and relief shading,	*NOTE 1*:Topography shall be formally expressed with the four elements 'local topography', 'relative elevation', 'topographic context', and 'altitude/depth' *NOTE 2:* The term 'altitude' is used for elevations above mean sea level. The term 'depth' is used for elevations below mean sea level. *EXAMPLES (can be converted into entries of the code table):* "a ridge at low relative elevation within valleys of middle altitude" "a depression within plains of very low depth"	4-03	C (Phase 3)
4-04	Exposure of instruments	The degree to which an instrument is affected by external influences and reflects the value of the observed quantity	*NOTE:* The exposure of an instrument results from joint appraisal of the environment, measurement interval and exposure against the requirements of some particular application. Expressed in terms of code table.	4-04	C (Phase 2)
4-05	Intervention at station/platform	Description of human or natural intervention in the vicinity or at the station that may influence the observed quantity		4-05 or free text	O (Phase 2)
4-06	Site information	Non-formalized information about the location and its surroundings at which an observed quantity is measured and may influence it.	*EXAMPLES:* e.g., maps, plans, photographs, descriptions and other unique site information that is difficult to express in words or that cannot easily be quantified. *NOTE 1:* This information may be frequently changing (for example ocean debris impacting buoys). *NOTE 2:* In hydrology, description and dating of activities occurring in the basin that can affect the observed discharge, e.g., construction of a regulation structure upstream of the gauging location that significantly affects the hydrological regime, inter-basin diversion of water into or from the basin upstream of the gauging location, significant change in consumptive use, land cover or land use.		O (Phase 2)

Condition

Either {4-01 and 4-02 and 4-03 and 4-04} or a nilReason="not applicable" must be reported. For hydrology and satellite observations, specifying nilReason is appropriate.

Code list definitions

Code table: 4-01-01

Code table title: Land cover types (IGBP)

#	Name	Definition
4-01-01-00	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)
4-01-01-01	Water	Cf. https://lpdaac.usgs.gov/products/modis_products_table/mcd12q1
4-01-01-02	Evergreen Needleleaf forest	
4-01-01-03	Evergreen Broadleaf forest	
4-01-01-04	Deciduous Needleleaf forest	
4-01-01-05	Deciduous Broadleaf forest	
4-01-01-06	Mixed forest	
4-01-01-07	Closed shrublands	
4-01-01-08	Open shrublands	
4-01-01-09	Woody savannas	
4-01-01-10	Savannas	
4-01-01-11	Grasslands	
4-01-01-12	Permanent wetlands	
4-01-01-13	Croplands	
4-01-01-14	Urban and built-up	
4-01-01-15	Cropland/Natural vegetation mosaic	
4-01-01-16	Snow and ice	
4-01-01-17	Barren or sparsely vegetated	
4-01-01-99	Unclassified	

Code table: 4-01-02
Code table title: Land cover types (UMD)

#	Name	Definition
4-01-02-00	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)
4-01-02-01	Water	Cf. https://lpdaac.usgs.gov/products/modis_products_table/mcd12q1
4-01-02-02	Evergreen Needleleaf forest	
4-01-02-03	Evergreen Broadleaf forest	
4-01-02-04	Deciduous Needleleaf forest	
4-01-02-05	Deciduous Broadleaf forest	
4-01-02-06	Mixed forest	
4-01-02-07	Closed shrublands	
4-01-02-08	Open shrublands	
4-01-02-09	Woody savannas	
4-01-02-10	Savannas	
4-01-02-11	Grasslands	
4-01-02-12	Croplands	
4-01-02-13	Urban and built-up	
4-01-02-14	Barren or sparsely vegetated	
4-01-02-99	Unclassified	

Code table: 4-01-03
Code table title: Land cover types (LAI/fPAR)

#	Name	Definition
4-01-03-00	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)
4-01-03-01	Water	Cf. https://lpdaac.usgs.gov/products/modis_products_table/mcd12q1
4-01-03-02	Grasses/Cereal crops	
4-01-03-03	Shrubs	
4-01-03-04	Broadleaf crops	
4-01-03-05	Savanna	
4-01-03-06	Evergreen broadleaf forest	
4-01-03-07	Deciduous broadleaf forest	
4-01-03-08	Evergreen needleleaf forest	
4-01-03-09	Deciduous needleleaf forest	
4-01-03-10	Non vegetated	
4-01-03-11	Urban	
4-01-03-99	Unclassified	

Code table: 4-01-04
Code table title: Land cover types (NPP)

#	Name	Definition
4-01-04-00	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)
4-01-04-01	Water	Cf. https://lpdaac.usgs.gov/products/modis_products_table/mcd12q1
4-01-04-02	Evergreen needleleaf vegetation	
4-01-04-03	Evergreen broadleaf vegetation	
4-01-04-04	Deciduous needleleaf vegetation	
4-01-04-05	Deciduous broadleaf vegetation	
4-01-04-06	Annual broadleaf vegetation	
4-01-04-07	Non-vegetated land	
4-01-04-08	Urban	
4-01-04-99	Unclassified	

Code table: 4-01-05
Code table title: Land cover types (PFT)

#	Name	Definition
4-01-05-00	Water	None of the codes in the table are applicable in the context of this particular observation (nilReason)
4-01-05-01	Evergreen Needleleaf trees	Cf. https://lpdaac.usgs.gov/products/modis_products_table/mcd12q1
4-01-05-02	Evergreen Broadleaf trees	
4-01-05-03	Deciduous Needleleaf trees	
4-01-05-04	Deciduous Broadleaf trees	
4-01-05-05	Shrub	
4-01-05-06	Grass	
4-01-05-07	Cereal crops	
4-01-05-08	Broad-leaf crops	
4-01-05-09	Urban and built-up	
4-01-05-10	Snow and ice	
4-01-05-11	Barren or sparse vegetation	
4-01-05-254	Unclassified	
4-01-05-255	Fill Value	

Code table: 4-01-06
Code table title: Land cover types (LCCS)

#	Name	Definition
4-01-05-00	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)
4-01-05-01	Cultivated and Managed Terrestrial Areas	cf. Antonio Di Gregorio (2005)
4-01-05-02	Natural and Semi-Natural Terrestrial Vegetation	
4-01-05-03	Cultivated Aquatic or Regularly Flooded Areas	
4-01-05-04	Natural and Semi-Natural Aquatic or Regularly Flooded Vegetation	
4-01-05-05	Artificial Surfaces and Associated Areas	
4-01-05-06	Bare Areas	
4-01-05-07	Artificial Waterbodies, Snow and Ice	
4-01-05-08	Natural Waterbodies, Snow and Ice	
4-01-05-99	Unclassified	

Code table: 4-03-01
Code table title: Local topography (based on Speight 2009)

#	Name	Definition
4-03-01-0	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)
4-03-01-1	Hilltop	Higher than all or nearly all of the surrounding land or subsurface.
4-03-01-2	Ridge	Higher than all or nearly all of the surrounding land or subsurface, but elongated and extending beyond a 50 m radius.
4-03-01-3	Slope	Neither crest nor depression or valley bottom, and with a slope more than 3%.
4-03-01-4	Flat	Slope less than 3% and not a top, ridge, valley bottom or depression. Use for plains.
4-03-01-5	Valley bottom	Lower than nearly all of surrounding land or subsurface, but water can flow out.
4-03-01-6	Depression	Lower than surrounding land or subsurface, with no above-ground outlet for water.

Code table: 4-03-02
Code table title: Relative elevation

#	Name	Definition
4-03-02-0	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)
4-03-02-1	Lowest	In the bottom 5% of the elevation range
4-03-02-2	Low	Between 5% and 25% of the elevation range
4-03-02-3	Middle	Between 25% and 75% of the elevation range
4-03-02-4	High	Between 75% and 95% of the elevation range
4-03-02-5	Highest	In the highest 5% of the elevation range

Code table: 4-03-03
Code table title: Topographic context (based on Hammond 1954)

#	Name	Definition
4-03-03-0	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)
4-03-03-1	Plains	Very low relief
4-03-03-2	Hollows	Low relief, tending to convergent form
4-03-03-3	Rises	Low relief, tending to divergent form
4-03-03-4	Valleys	Medium relief, tending to convergent form
4-03-03-5	Hills	Medium relief, tending to divergent form
4-03-03-6	Mountains	High relief

Code table: 4-03-04
Code table title: Altitude/Depth

#	Name	Definition
4-03-04-0	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)
4-03-04-1	Very small	between –100 m and 100 m
4-03-04-2	small	Between –300 and –100 m or between 100 and 300 m
4-03-04-3	Middle	Between –1000 and –300 m or between 300 and 1000 m
4-03-04-4	large	Between –3000 and –1000 m Between 1000 and 3000 m
4-03-04-5	Very large	Deeper than –3000 m or above 3000 m

Code table: 4-04
Code table title: Exposure of instrument

#	Name	Definition
4-04-1	Class 1	exposure of instrument allows reference level measurements
4-04-2	Class 2	exposure of instrument has small or infrequence influence on measurement
4-04-3	Class 3	exposure of instrument leads to increased uncertainty or occasional invalid measurements
4-04-4	Class 4	exposure of instrument leads to high uncertainty or regular invalid measurements
4-04-5	Class 5	exposure of instrument leads to invalid measurements

Code table: 4-05
Code table title: Intervention at station/platform [Code table under development]

#	Name	Definition
4-05-01	Grass-cutting	
4-05-02	Snow clearing	
4-05-03	Tree removal	
4-05-04	Construction activity	
4-05-05	Road work	
4-05-06	Biomass burning	Anthropogenic or natural
4-05-07	Dust storm	
4-05-08	Storm damage	
	Wind storm	
	Flood	
	Fire	
	Earthquake	
	Land slide	
	Storm surge or tsunami	
	Lightning	
	Vandalism	
…	…	

Category 5: Data Processing and Reporting

Specifies how raw data are transferred into the reported physical quantities and reported to the users.

Id	Name	Definition	Note or Example	Code table	ItemMCO
5-01	Data processing methods and algorithms	A description of the processing applied to the observed quantity and list of algorithms utilized to derive the resultant value.	*NOTE*: In hydrology, this would be the equation(s) defining the rating curve and any shifts or corrections applied to the data or the curve.		O (Phase 3)
5-02	Processing/analysis centre (eg chemical analysis, transform to physical variables)	Location/center at which the observed quantity is transformed from input to end result.	*EXAMPLES*: Chemical analysis, AMDAR processing centre, National Hydrological Service office		O (Phase 2)
5-03	Temporal reporting interval	Time interval at which the observed quantity is reported	*EXAMPLES*: Hourly, daily, monthly, seasonal, event-based, 80 seconds interval during the day, etc.	5-03	M* (Phase 1)
5-04	Spatial reporting interval	Spatial interval at which the observed quantity is reported	*NOTE*: This is applicable only to remote sensing observations and mobile platforms in general. For most remote-sensing observations, this will be redundant with element 6-06. *EXAMPLES:* – An observation from a satellite may be reported with a spatial resolution of 10 km x 20 km. – An aircraft may sample every 1 km along its trajectory (cf. 6-06), but may report at a spatial interval of 10 km.		C* (Phase 1)
5-05	Software/processor and version	Name and version of the software or processor utilized to derive the element value.	*EXAMPLES*: Avionics version, retrieval algorithm version; MCH Database Management System version 25/10/2013.		O (Phase 3)

Id	Name	Definition	Note or Example	Code table	ItemMCO
5-06	Level of data	Level of data processing	*NOTE:* Pre or Post processing	5-06	O (Phase 2)
5-07	Data format[2]	Description of the format in which the observed quantity is being provided.	*EXAMPLES*: ASCII, BUFR, NASA AMES, HDF, XML, AMDAR, comma-separated (CSV), tab-separated (.txt), MCH (for interchange)		M (Phase 3)
5-08	Version of data format[3]	Version of the data format in which the observed quantity is being provided.	*EXAMPLES*: FM 12–XIV Ext. SYNOP; FM 42-XI Ext. AMDAR, FM 94-XIV BUFR Version 20.0.0, Radar: ODIM_H5		M (Phase 3)
5-09	Aggregation interval	Time period over which data is collected	*EXAMPLES*: 5 minute mean, daily maximum, seasonal, event based		M (Phase 2)
5-10	Meaning of time stamp	The time period reflected by the time stamp.		5-10	M (Phase 2)
5-11	Reference time	Time base to which date and time stamps refer	*NOTE:* The reference time must not be confounded with the time zone (which is part of the representation of the time stamp), but indicates what the source of the time stamp is, i.e., to which reference time the time stamps of the observation are aligned. *EXAMPLES*: NIST time server NTP pool project		M (Phase 2)
5-12	Reference datum	Reference datum used to convert observed quantity to reported quantity	*EXAMPLES*: – QFE/QNH – Hydrology gauge zero		C (Phase 1)
5-13	Numerical resolution	Measure of the detail in which a numerical quantity is expressed.	*NOTE 1*: The resolution of a numerical quantity is a measure of the detail in which the quantity is expressed. It can be expressed as the smallest possible		O (Phase 3)

[2] Provided as part of the WIS metadata records

[3] Provided as part of the WIS metadata records

Id	Name	Definition	Note or Example	Code table	ItemMCO
			difference between two numbers. It can also be expressed as the number of significant figures of a number, which are those digits that carry meaning contributing to its resolution. *EXAMPLE*: if a measurement resolution to four decimal places (0.0001) is given as 12.23 then it might be understood that only two decimal places of resolution are available. Stating the result as 12.2300 makes clear that it is precise to four decimal places (in this case, six significant figures). *NOTE 2*: The notion of measurement resolution is related but must not be confounded with the uncertainty of an observation *EXAMPLES*: – An anemometer may measure wind speed with a measurement resolution of 0.1 ms^{-1} with a 1 Hz scan rate. Observations may be aggregated to 1-minute values and may be rounded and reported with a (reduced) measurement resolution of 1 ms^{-1}. – A barometer may be capable of measuring atmospheric pressure with a readout resolution of 1 hPa and an uncertainty of 5 hPa (k=2). The data can be reported to the nearest hPa, however, the measurement resolution should be stated as “5 hPa” or “3 significant digits”. – An ocean thermometer measures temperature to 0.0001 °C. – Seawater salinity measured to 0.001 salinity units (derived from conductivity measurements with a resolution of 0.01 Sm^{-1})		

Id	Name	Definition	Note or Example	Code table	ItemMCO
5-14	Latency (of reporting)	The typical time between completion of the observation or collection of the datum and when the datum is reported.	(i) For satellite data, the "observation" (e.g. a complete image) can take 20 minutes to generate. Hence the latency would be the time between the completion of the image collection, and when it is available. Typically this can be 2-3 minutes. Some satellite products such as SST can take about 10 minutes of processing until it is available. (ii) A radar volumetric scan can take 6 – 10 minutes (in Australia), so the latency would be the time between the completion of the scan and when the data is locally available. In Australia, this varies between a few seconds to several minutes depending on delays in data communications. (iii) AWS data may have a latency of 1– 20 seconds (or considerably more in some places) between the completion of the observation and arrival of the data at a central archive.	5-14	M (Phase 3)

Conditions
{5-04}: mandatory for remote sensing observations and mobile platforms in general
{5-12}: mandatory for stations/platforms that report a derived observation value that depends on a local datum

Code list definitions

Code table: 5-03
Code table title: Temporal reporting interval
[Code table under development]

Code table: 5-06
Code table title: Level of data

#	Name	Definition	
		CIMO (WMO No. 8, 2008, Updated 2010)	**CEOS** (http://www.ceos.org/images/WGISS/Documents/Handbook.pdf)
5-06-0	Unknown		
5-06-1	Raw		Physical information: Data in their original packets, as received from a satellite
5-06-2	Level 0	Analogue/digital electric signals	Physical information: Reconstructed unprocessed instrument data at full space time resolution with all available supplemental information to be used in subsequent processing (e.g., ephemeris, health and safety) appended.
5-06-3	Level I	Level I data (Primary Data): in general, are instrument readings expressed in appropriate physical units, and referred to Earth geographical coordinates. They require conversion to the normal meteorological variables (identified in Part I, Chapter 1). Level I data themselves are in many cases obtained from the processing of electrical signals such as voltages, referred to as raw data. Examples of these data are satellite radiances and water-vapour pressure, positions of constant-level balloons, etc. but not raw telemetry signals. Level I data still require conversion to the meteorological parameters specified in the data requirements.	Physical information: Unpacked, reformatted level 0 data, with all supplemental information to be used in subsequent processing appended. Optional radiometric and geometric correction applied to produce parameters in physical units. Data generally presented as full time/space resolution. A wide variety of sub level products are possible.
5-06-4	Level II	Level II Data (Meteorological parameters). They may be obtained directly from many kinds of simple instruments, or derived from Level I data. For example, a sensor cannot measure visibility, which is a Level II quantity; instead, sensors measure the extinction coefficient, which is a Level I quantity.	Geophysical information. Retrieved environmental variables (e.g., ocean wave height, soil moisture, ice concentration) at the same resolution and location as the level 1 source data.
5-06-5	Level III	Level III (Initial state parameters) are internally consistent data sets, generally in grid-point form obtained from level II data by applying established initialization procedures. NOTE: Data exchanged internationally are level II or level III data.	Geophysical information. Data or retrieved environmental variables which have been spatially and/or temporally re-sampled (i.e., derived from level 1 or 2 products). Such re-sampling may include averaging and compositing.
5-06-6	Level IV		Thematic information. Model output or results from analyses of lower level data (i.e., variables that are not directly measured by the instruments, but are derived from these measurements).

Code table: 5-10
Code table title: Meaning of time stamp

#	Name	Definition
5-10-1	Beginning	Time stamps indicate the beginning of a period covering the range up to but excluding the following time stamp
5-10-2	End	Time stamps indicate the end of a period covering the range up to but excluding the preceding time stamp
5-10-3	Middle	Time stamps indicate the middle of a period beginning at the middle of the range described by this and the preceding time stamp and ending right before the middle of the range described by this and the following time stamp.

Code table: 5-14
Code table title: Latency (of reporting)
[Code table under development]

Category 6: Sampling and Analysis

Specifies how sampling and/or analysis are used to derive the reported observation or how a specimen was collected.

Id	Name	Definition	Note or Example	Code Table	ItemMCO
6-01	Sampling procedures	Procedures involved in obtaining a sample	*EXAMPLES*: Temperature measurements are made using a XYZ thermometer and reported results are an average of 10 measurements made in a given hour. Aerosols may be sampled with an inlet with size-cutoff at 2.5 µm and be deposited on a teflon filter. Manual reading of a liquid-in-glass thermometer every three hours.		O (Phase 3)
6-02	Sample treatment	Chemical or physical treatment of sample prior to analysis	*EXAMPLES*: Homogenization, milling, mixing, drying, sieving, heating, melting, freezing, evaporation, sanity check (range, jumps)…		O (Phase 3)
6-03	Sampling strategy	The strategy used to generate the observed quantity.	*EXAMPLES*: – global radiation, pressure, or continuous ozone monitoring with a UV monitor – gas chromatographic analysis of carbon monoxide, etc – grab water samples, flask sampling of air, etc.	6-03	O* (Phase 1)
6-04	Sampling time period	The period of time over which a measurement is taken	*EXAMPLES*: surface winds sampled every 0.25 s (frequency 4 Hz) (WMO, 2008); surface winds measured once per hour; Barometric pressure measured once every 6 minutes; water column height measured every 15 seconds; water temperature measured once per hour (NOAA, 2009);		M# (Phase 3)
6-05	Meaning of the time stamp	The time period reflected by the time stamp. (cf. 5-10)	*EXAMPLES*: Wind measurement is reported at 10Z (an average of measurements made at 6-minute intervals form 0906Z – 1000Z). Beginning, middle, end of period. 5-minute mean, daily maximum, seasonal.	6-05 (5-10)	M# (Phase 3)

Id	Name	Definition	Note or Example	Code Table	ItemMCO
6-06	Spatial sampling resolution	Spatial resolution refers to the size of the smallest observable object. The intrinsic resolution of an imaging system is determined primarily by the instantaneous field of view of the sensor, which is a measure of the ground area viewed by a single detector element in a given instance in time.	*EXAMPLES*: AVHRR: 1.1 km IFOV s.s.p. The sample is a point in space or a very small volume resembling a point, e.g., a temperature sampled by a thermocouple element: No size to be reported; The sample is a line, either straight (e.g., a line of sight of a DOAS instrument) or curved (e.g., the humidity sampled by an aircraft in flight). The 'length' of the line is to be reported; The sample is an area, either rectangular or of any other shape, e.g., the pixel of a satellite or the reach of a radar image. The 'length x length' of the area is to be reported; The sample is a volume, e.g. a water sample or a well-mixed volume of air sampled by flask. The 'length x length x length' of the volume is to be reported.		M[#] (Phase 2)
6-07	Analytical procedures	Description of procedure used	*EXAMPLES*: Water sample – physical or chemical analyses for excess minerals, toxins, turbidity, colour – accomplished in a laboratory or by conducting a field test. Water sample – bacteriological analyses – coliform bacteria using a) Standard Plate Count or b) Multiple Tube Method using one of three tests (1) Presumptive Test (2) Confirmed Test (3) Complete Test (Ref: Water for the World Technical Note "Water Sample Analysis" No. RWS.3.P.3) Gas chromatography, ion chromatography, photometry	6-07	O (Phase 3)
6-08	Temporal sampling interval	Time period between the beginning of consecutive sampling periods			M (Phase 3)

Code list definitions

Code table: 6-03
Code table title: Sampling strategy

#	Name	Definition
6-03-1	Continuous	Sampling is done continuously, but not necessarily at regular time intervals. Sampling is integrating, i.e., none of the medium escapes observations.
6-03-2	Discrete	Sampling is done at regular time intervals for certain sampling periods that are smaller than the time interval. Sampling is not integrating, i.e., parts of the medium escape observation.
6-03-3	Event	Sampling is done at irregular time intervals in a quasi-instantaneous manner.

Code table: 6-07
Code table title: Analytical procedures
[Code table under development]

Category 7: Station/Platform

Specifies the environmental monitoring facility, including fixed station, moving equipment or remote sensing platform at which an observation is made.					
Id	Name	Definition	Note or Example	Code Table	ItemMCO
7-01	Region of origin of data	WMO Region.	*NOTE:* WMO divides Member countries into six Regional Associations responsible for coordination of meteorological, hydrological and related activities within their respective Regions.	7-01	C* (Phase 1)
7-02	Territory of origin of data	Country or territory name of the location of the observation	*EXAMPLE*: Australia. *NOTE*: Mandatory for fixed stations, optional for mobile stations	7-02	C* (Phase 1)
7-03	Station/platform name	Official name of a station/platform.	*EXAMPLES*: Mauna Loa, South Pole		M (Phase 1)
7-04	Station/platform type	A categorization of the type of environmental monitoring facility at which an observed quantity is measured.	*NOTE*: Code table according to See [INSPIRE D2.8.III.7, 2013]	7-04	M* (Phase 2)
7-05	Station/platform model	The model of the monitoring equipment used at the station/platform.	*EXAMPLES*: ‘Landsat 8’ is a platform/station model of ‘satellite’; ‘Almos Automatic Weather Station (AWS)’ is a model of a ‘land station’; ’Airbus A340-600’ is a model of an ‘aircraft’.		M*# (Phase 3)
7-06	Station/platform unique identifier	A unique and persistent identifier for an environmental monitoring facility (station/platform), which may be used as an external point of reference.	*NOTE 1*: A globally unique identifier assigned by WMO for a station. Where a station has multiple identifiers, there must be a way of recording that they are synonyms. To be defined according to WMO guidelines. *EXAMPLE*: Ship: Call sign.		M* (Phase 1)
7-07	Geospatial location	Position in space defining the location of the environmental monitoring station/ platform/ facility at the time of observation.	*NOTE 1*: Required for fixed stations; for stations following pre-determined trajectory (e.g. satellites); *NOTE 2*: The elevation of a fixed terrestrial station is defined as the height above sea level of the ground on which the station stands. *NOTE 3*: The geospatial location can be a zero-, one-, two-, or three-dimensional feature.		M* (Phase 1)

Id	Name	Definition	Note or Example	Code Table	ItemMCO
			NOTE 4: Geographical coordinates can be specified in decimal degrees or in degrees, minutes and decimal seconds. Latitudes are specified with reference to the equator, with positive sign for latitudes north of the equator, and negative sign for latitudes south of the equator. Longitudes are specified with reference to the Greenwich meridian, with positive sign for longitudes east of Greenwich, and negative sign for meridians west of Greenwich. Elevation is a signed number specified in some distance measure (e.g., meters) relative to a reference elevation. *NOTE 5*: The latitudinal and longitudinal positions of a station referred to in the World Geodetic System 1984 (WGS-84) Earth Geodetic Model 1996 (EGM96) must be recorded to a resolution of at least 0.001 decimal degrees (WMO No.8, 2008, Part I, Chapter 1, 1.3.3.2). *EXAMPLES:* (i) The station Jungfraujoch is located at 46.54749°N 7.98509°E (3580 m a.m.s.l.). The reference system is WGS-84. (ii) Voluntary Observing Ship Route: WMO Regional Association 5, Sub Area 6 (R56) (iii) [geostationary satellite] Meteosat-8 (MSG-1) 3.6°E (iv) [sunsynchronous satellite] NOAA-19 Height 870 km; Local Solar Time (LST) 13:39 ii) Weather Watch Radar: Warruwi NT –11.6485° N, 133.3800 E, Height 19.1 m amsl. iv) River discharge gauge: Warrego River at Cunnamulla Weir 28.1000 S, 145.6833 E, Height: 180 m amsl.		
7-08	Data communication method	Data communication method between the station/platform and some central facility	*EXAMPLES*: Inmarsat-C, ARGOS, Cellular, Globalstar, GMS(DCP), Iridium, Orbcomm, VSat, landline telephone, mail	7-08	O (Phase 2)

Condition
{7-01, 7-02}: Mandatory for fixed land-based stations, optional for mobile stations

Code list definitions

Code table: 7-01
Code table title: Region of origin of data

#	Name	Definition
7-01-1	I	Africa
7-01-2	II	Asia
7-01-3	III	South America
7-01-4	IV	North America, Central America and the Caribbean
7-01-5	V	South-West Pacific
7-01-6	VI	Europe
7-01-7	VII	Antarctica

Code table: 7-02
Code table title: Territory of origin of data
[Code table under development]

Code table: 7-04
Code table title: Station/platform type (simplified) [WMO No 306]

#	Name	Definition
7-04-1	land station	An observing station or field site situated on land, either fixed or mobile.
7-04-2	sea station	An observing station situated at sea. Sea stations include ships, ocean weather stations and stations on fixed or drifting platforms (rigs, platforms, lightships and buoys).
7-04-3	aircraft	An airplane, helicopter or airship used to make environmental observations.
7-04-4	satellite	A platform placed in orbit around the earth to make environmental observations.
7-04-5	underwater platform	A platform under a lake or sea surface, including autonomous underwater vehicles.

Code table: 7-08
Code table title: Data communication method
[Code table under development]

Category 8: Method of Observation

Specifies the method of observation and describes characteristics of the instrument(s) used to make the observation. If multiple instruments need to operate in concert to arrive at an observation, then this category should be repeated.

Id	Name	Definition	Note or Example	Code Table	ItemMCO
8-01	Source of observation	The source of the dataset described by the metadata	*NOTE:* Refer to the Code table	8-01	M (Phase 1)
8-02	Measurement/observing method	The method of measurement/observation used.	*EXAMPLES:* Temperature can be determined using different principles: liquid in glass; mechanical; electrical resistance; thermistor; thermocouple. Likewise, humidity is determined in AMDAR as amass mixing ratio. Several chemical variables can be determined using infrared absorption spectroscopy. In hydrology, stage would be observed using a staff gauge, electric tape, pressure transducer, gas bubbler, or acoustics. Examples of satellite observation principles: Cross-nadir scanning IR sounder; MW imaging/sounding radiometer, conical scanning, etc. Visual observation of weather, cloud type, etc	8-02	M[#] (Phase 1)
8-03	Observable range	Intrinsic capability of the measurement/observing method to measure the designated element	*NOTE 1*: The metadata record can be "not available". *NOTE 2*: Includes the Upper limit of operational range and the Lower limit of operational range *EXAMPLES:* 1) Barometer measurement range 800-1100 hPa (i.e. unsuitable for some mountain ranges, Mt Everest ~300hPa) 2) Maximum distance a human observer can observe given the topography.		M*[#] (Phase 1)

Id	Name	Definition	Note or Example	Code Table	ItemMCO
8-04	Instrument stability	The ability of an instrument to maintain its metrological characteristics constant with time	*EXAMPLE:* - Ozone analyzer		C* (Phase 1)
8-05	Vertical distance of sensor	Vertical distance of the sensor from the reference level specified under 7-07 or 8-12 or the mean sea level. It is the actual height above local ground, or deck of a marine platform, at the point where the sensor is located.	*NOTE 1:* The reference surface (generally a surface which will strongly influence the observation) must be specified. *NOTE 2:* Away from center of earth, positive. *EXAMPLES:* i) Air temperature: height of the temperature sensor is 1.5 m above ground surface (station level). ii) Surface wind: 10.0 m above ground surface (station level) iii) Soil temperature: 0.50 m below soil surface; iv) Ship: Visual Obs Height: 22.0 m a.s.l. v) Weather Watch Radar: Warruwi AU 24.3 m above ground surface (see 7-07) vi) Transmissometer 2.5 above runway surface vii) depth of buoy relative to lowest astronomical tide viii) Pressure sensor: vertical distance above mean sea level ix) For satellites, e.g., geostationary orbit at 36000 km above geoid, or LEO at 800 km above geoid		C* (Phase 1)
8-06	Configuration of instrumentation	Description of any shielding or configuration/setup of the instrumentation or auxiliary equipment needed to make the observation or to reduce the impact of extraneous influences on the observation	*EXAMPLES:* shelter, temperature control, etc. Internal volume: [m^3] Aspirated: [Natural/forced/na] Aspiration rate: m^3s^{-1} Shielding from: [radiation/precipitation/ wind/etc.] Inlet Characteristics		C# (Phase 3)

Id	Name	Definition	Note or Example	Code Table	ItemMCO
8-07	Lab calibration schedule	Description of schedule for lab calibrations of instrument	*EXAMPLE:* Every year on first week of February		C (Phase 3)
8-08	Instrument lab calibration date, time and validity	Date/time of the most recent calibration [and the period of validity	*NOTE 1:* record even if "not available" *NOTE 2:* Use the format: YYYYMMDD HH:MM UTC *EXAMPLE:* *20140207 15:30 UTC,* Validity: 4 years		C# (Phase 3)
8-09	Instrument model and serial number	Details of manufacturer, model number, serial number and firmware version if applicable.	*NOTE 1*: Record "not available" NOTE 2: Use the following formats: Instrument manufacturer: [free text] Instrument model: [free text] Instrument serial number: [free text] Firmware version: [free text] *EXAMPLE*: Vaisala PTB330B G2120006		C# (Phase 3)
8-10	Instrument field maintenance	A description of maintenance that is routinely performed on an instrument.	*EXAMPLE*: Daily cleaning of a radiation sensor.		C# (Phase 3)
8-11	Instrument field verification date and time	Date/time of most recent field verification with travelling standard	*NOTE 1*: Use even if installation date *NOTE 2*: Use the following format: YYYYMMDD HH:MM UTC *NOTE 3*: Information should contain at least the following elements: Standard type: [International, Primary, Secondary, Reference, Working, Transfer, Travelling, collective] Standard name: [free text] Standard reference: [serial number or equivalent] Within verification limit [Y/N] *NOTE 4*: Can be implemented with a URI pointing to a document containing this information		C# (Phase 3)

Id	Name	Definition	Note or Example	Code Table	ItemMCO
8-12	Geospatial location	Geospatial location of instrument/sensor	*NOTE:* Geographic location of instrument such as airfield anemometer or transmissometer. *EXAMPLES:* 1) Melbourne Airport AU (East anemometer) –37.6602 N, 144.8443 E, 122.0 m amsl. 2) relative position of wind sensor aboard ship 3) 30 km upstream of river mouth		C* (Phase 2)

Condition
{8-04, 8-07, 8-08, 8-09, 8-10, 8-11} mandatory for instrumental observations
{8-05} mandatory for instrumental observations and if proximity of reference surface impacts on observation
{8-06} mandatory for instrumental observations and if prescribed by “best practice”.
{8-12} mandatory for instrumental observations and if different from station/platform

Code list definitions

Code table: 8-01
Code table title: Source of observation

#	Name	Definition
8-01-1	Automatic observation	Automatically produced measurement result
8-01-2	Manual observation	Manual reading of instrument
8-01-3	Visual observation	Human, non-instrumented observation

Code table: 8-02
Code table title: Measurement/observing method
[Code table under development]

Category 9: Ownership & Data Policy

Specifies who is responsible for the observation and owns it.

Id	Name	Definition	Note or Example	Code Table	ItemMCO
9-01	Supervising organization	Name of organization who owns the observation	*NOTE 1:* To be modelled as *gmd:CI_ResponsibleParty* (NOAA, 2011). Here, this will be */gmd:MD_Metadata/gmd:contact* */gmd:MD_Metadata/gmd:contact//gmd:role = "pointOfContact"* *NOTE 2:* It is recommended that */gmd:MD_Metadata/gmd:identificationInfo//gmd:pointOfContact* should provide a minimum of a name and an e-mail address. (WMO, 2013b)] *EXAMPLES:* *for satellite operators* EUMETSAT, ESA, NOAA, NASA, CMA, RapidEye, ISRO		M (Phase 2)
9-02	Data policy/use constraints	Details relating to the use and limitations surrounding the imposed by the supervising organization or governing body.	*NOTE 1:* Shall be modeled as */gmd:MD_Metadata/gmd:identificationInfo//gmd:resourceConstraints//gmd:otherConstraints* *NOTE 2:* Only one single use constraint with a value taken from WMO_DataLicenseCode is allowed to ensure unambiguity. (WMO, 2013b, p15)	9-02	M* (Phase 1)

<u>Code list definitions</u>

Code table: 9-02
Code table title:WMO_DataLicenseCode (WMO 2013c, Table 14)

#	Name	Definition
9-02-1	WMOEssential	WMO Essential Data: free and unrestricted international exchange of basic data and products.
9-02-2	WMOAdditional	WMO Additional Data: free and unrestricted access to data and products exchanged under the auspices of WMO to the research and education communities for non-commercial activities. A more precise definition of the data policy may be additionally supplied within the metadata. In all cases it shall be the responsibility of the data consumer to ensure that they understand the data policy specified by the data provider – which may necessitate dialogue with the data publisher for confirmation of terms and conditions.
9-02-3	WMOOther	Data identified for global distribution via WMO infrastructure (GTS / WIS) that is not covered by WMO Resolution 25 neither WMO Resolution 40; e.g. aviation OPMET data. Data marked with "WMOOther" data policy shall be treated like "WMOAdditional" where a more precise definition of the data policy may be additionally supplied within the metadata. In all cases it shall be the responsibility of the data consumer to ensure that they understand the data policy specified by the data provider – which may necessitate dialogue with the data publisher for confirmation of terms and conditions.

Category 10: Contact

Specifies where information about an observation or dataset can be obtained.					
Id	Name	Definition	Note or Example	Code Table	ItemMCO
10-01	Contact (Nominated Focal Point)	Principal contact (Nominated Focal Point, FP) for resource	*NOTE 1:*To be modeled as *gmd:CI_ResponsibleParty* (NOAA, 2011). Here, this will be */gmd:MD_Metadata/gmd:contact* */gmd:MD_Metadata/gmd:contact//gmd:role = "pointOfContact"* *NOTE 2:* It is recommended that */gmd:MD_Metadata/gmd:identificationInfo//gmd:pointOfContact* should provide a minimum of a name and an e-mail address. *EXAMPLES:* Programme or Network Manager, e.g. E-AMDAR Technical Coordinator (TC) has responsibility for data quality of several airlines' fleets, has information on aircraft type/software/known errors etc. *NOTE 3:* The FP would be able to provide data users with information regarding individual observing platforms.		M (Phase 3)

VIII – References

Antonio Di Gregorio (2005), Land Cover Classification System. Classification concepts and user manual. Software version 2, Food and Agricultural Organization of the United Nations, ISBN 92-5-105327-8, 212pp, http://www.glcn.org/downs/pub/docs/manuals/lccs/LCCS2-manual_en.pdf

Bannerman, B. (2012). Stations Metadata and WMO Core Profile, A Way Forward (discussion paper). Retrieved May 20, 2014, from http://www.wmo.int/pages/prog/wcp/wcdmp/documents/etcdms-metadata-discussionpaper.pdf

Dornblut, I. (2013). Hydrologic Information – Metadata. Semantic structure for the description of hydrologic data (GRDC Hydrologic Metadata). Koblenz, Germany: Federal Institute of Hydrology (BfG).

Fenix, J. L. (2006, June 8). The National Weather Service Gateway: A history in communications technology evolution. Retrieved May 20, 2014, from NOAA History: http://www.history.noaa.gov/stories_tales/gateway.html

FRA (2000), Forest cover mapping & monitoring with NOAA-AVHRR& other coarse spatial resolution sensors, Forest Resources Assessment Programme Working Paper 29, http://www.fao.org/forestry/4031-0b6287f13b0c2adb3352c5ded18e491fd.pdf

GCOS. (2003). GCOS Monitoring Principles. Retrieved May 20, 2014, from http://www.wmo.int/pages/prog/gcos/index.php?name=ClimateMonitoringPrinciples

Hammond, E.H. (1954) Small-scale continental landform maps, *Annals of the Association of American Geographers,* 44(1):33-42. DOI:10.1080/00045605409352120

Hettich, N. (2013). WIR OSCAR/Space OSCAR/Requirements documentation extract (informal document).

IEC International Standard 60050-300 First edition 2001-07; International Electrotechnical Vocabulary – Electrical and electronic measurements and measuring instruments

INSPIRE – D2.8.III.7, 2013 Data Specification on Environmental Monitoring Facilities – Draft Technical Guidelines http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_EF_v3.0rc3.pdf. SpecialisedEMFTypeValue, p 33

ISO/TC 211. (2003). ISO 19115:2003, Geographic information – Metadata. Oslo, Norway: International Standards Organization.

ISO/TC 211. (2011). ISO19156:2011, Geographic Information – Observations and Measurements. Geneva, Switzerland: International Standards Organization.

James R. Anderson et al. (1976), A land use and land cover classification system for use with remote sensor data, Geological Survey Professional Paper 964, 27pp, http://books.google.de/books?id=dE-ToP4UpSIC

JCGM 100:2008. Evaluation of measurement data — Guide to the Expression of Uncertainty in Measurement, available at: http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf

JCGM 200:2012. International vocabulary of metrology — Basic and general concepts and associated terms (VIM), 3rd Edition, available at: http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf

Laj, P., Klausen, J., Bilde, M., Plass-Dülmer, C., Pappalardo, G., Clerbaux, C., et al. (2009). Measuring atmospheric composition change. Atmospheric Environment, 5351–5414.

M. Herold, R. Hubald, and G. Di Gregorio (2009), Translating and evaluating land cover legends using the UN Land Cover Classification system (LCCS), GOFC-GOLD Report Nr. 43, Jena, Germany, http://nofc.cfs.nrcan.gc.ca/gofc-gold/Report%20Series/GOLD_43.pdf

MODIS Land Cover Type Product: https://lpdaac.usgs.gov/products/modis_products_table/mcd12q1

NOAA (2009), "Handbook of Automated Data Quality Control Checks and Procedures" – Technical Document 09-02. National Data Buoy Center – Stennis Space Center, Mississippi 39529-6000. U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

NOAA (2011), Environmental Data Management Wikl – ISO 19115 Metadata Standard for Geographic Data: https://geo-ide.noaa.gov/wiki/index.php?title=File:CI_ResponsibleParty.png

Ramsey and Hewitt, 2005.Charles A. Ramsey and Alan D. Hewitt, A Methodology for Assessing Sample Representativeness, *Environmental Forensics*, 6:71–75, 2005, doi: 10.1080/15275920590913877

R Development Core Team. (2011). A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.

S. Henne, D. Brunner, D. Folini, S. Solberg, J. Klausen, and B. Buchmann, Assessment of parameters describing representativeness of air quality in-situ measurement sites, *Atmos. Chem. Phys*., 10, 3561–3581, 2010.

Speight, J.G. (2009) Landform, in *Australian Soil and Land Survey Field Handbook (3rd edn)*, National Committee on Soil and Terrain, CSIRO Publishing, Melbourne. http://www.publish.csiro.au/nid/22/pid/5230.htm, http://books.google.com.au/books?id=zywc39z4LgAC

WMO. (2003). Fourteenth World Meteorological Congress: Abridged Final Report with Resolutions (WMO-No. 960). Geneva, Switzerland: World Meteorological Organization.

WMO (2003a), Guidelines on Climate Metadata and Homogenization (WMO/TD-No.1186, WCDMP-53), Enric Aguilar, Inge Auer, Manola Brunet, Thomas C. Peterson, J. Wieringa. Geneva, Switzerland: World Meteorological Organization.

WMO. (2007). Fifteenth World Meteorological Congress: Abridged Final Report with Resolutions (WMO-No. 1026). Geneva, Switzerland: World Meteorological Organization.

WMO. (2007a). WMO/GAW Strategic Plan: 2008–2015 – A Contribution to the Implementation of the WMO Strategic Plan: 2008-2011 (GAW Report No. 172, WMO TD No. 1384). Geneva, Switzerland: World Meteorological Organization.

WMO (2008) Guide to Meteorological Instruments and Methods of Observation, (WMO-No. 8 – Updated 2010). Geneva, Switzerland: World Meteorological Organization.

WMO (2010), *Manual on the Global Data-Processing and Forecasting System* (WMO-No. 485): Volume I – Global aspects. Geneva, Switzerland: World Meteorological Organization.

WMO. (2011). Addendum for the Period 2012–2015 to the WMO Global Atmosphere Watch (GAW), WMO GAW Report Nr. 197. Geneva, Switzerland: Word Meteorological Organization.

WMO (2012), *Manual on Codes* (WMO-No. 306) – International Codes VOLUME I.1 PART A – Alphanumeric Codes ftp://ftp.wmo.int/Documents/MediaPublic/Publications/CodesManual_WMO_No_306/WMO306_Vol_I.1_2012_en.pdf. Geneva, Switzerland: World Meteorological Organization.

WMO (2013), *Manual on Codes* (WMO-No. 306) – International Codes VOLUME I.2 PART B – Binary Codes http://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/Publications/2011editionUP2013/WMO306_vI2_2011UP2013.pdf. Geneva, Switzerland: World Meteorological Organization.

WMO. (2013a). *Manual on the WMO Information System*: Annex VII to the WMO Technical Regulations. Geneva, Switzerland: World Meteorological Organization.

WMO. (2013b, January 15). WMO Core Metadata Profile version 1.3: Specification. Part 1 – Conformance Requirements. C.1.3-Part 1 to the Manual on the WMO Information System (WMO-No. 1060). Geneva, Switzerland: World Meteorological Organization. http://wis.wmo.int/2012/metadata/WMO_Core_Metadata_Profile_v1.3_Specification_Part_1_v1.0FINALcorrected.pdf

WMO. (2013c, January 15). WMO Core Metadata Profile version 1.3: Specification. Part 1 – Conformance Requirements. C.1.3-Part 1 to the *Manual on the WMO Information System* (WMO-No. 1060). Geneva, Switzerland: World Meteorological Organization. http://wis.wmo.int/2012/metadata/WMO_Core_Metadata_Profile_v1.3_Specification_Part_2_v1.0FINAL.pdf

WMO (2013d), *Weather Reporting* (WMO-No. 9), Volume A, Observing Stations. Geneva, Switzerland: World Meteorological Organization. http://www.wmo.int/pages/prog/www/ois/ois-home.html

WMO. (2014, May 19). Appendix 2.3 (The WIGOS Metadata Standard) to the Manual on WIGOS, draft version 2014-05-19. Retrieved May 26, 2014, from Task Team on WIGOS Regulatory Material (TT-WRM) of ICG-WIGOS (Updated 20 May 2014): http://www.wmo.int/pages/prog/www/wigos/TT-WRM.html

WMO. (2014a). WMO *Technical Regulations* Volume I Part 1, draft version 0.4 (presented to EC-66). Geneva, Switzerland: World Meteorological Organization.

WMO. (2014b). Manual on WIGOS, draft version 0.4 (presented to EC-66). Geneva, Switzerland: World Meteorological Organization.

ANNEX XI
Annex to paragraph 3.1.12 of the general summary

PROPOSED TEXT FOR INCLUSION IN THE MANUAL ON THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM REGARDING WIGOS STATION IDENTIFIERS

Members shall issue WIGOS station identifiers for observing stations and platforms within their geographic area of responsibility that contribute to a WMO or co-sponsored Programme and shall ensure that no WIGOS station identifier is issued to more than one station.

Note: Members may issue WIGOS station identifiers for observing stations and platforms within their geographic area of responsibility that do not contribute to a WMO or co-sponsored Programme, provided that the operator has committed to providing and maintaining WIGOS metadata.

Before issuing a station identifier, Members should ensure that the operator of a station or platform has committed to providing and maintaining WIGOS metadata for that station or platform and to conforming to relevant Technical Regulations.

Note: In circumstances when a WIGOS identifier is required for a station or platform to support a WMO or co-sponsored Programme and no Member is in a position to issue one (e.g. Antarctica), the Secretary-General may issue a WIGOS station identifier for that station or platform provided that its operator has committed to:

(a) Providing WIGOS metadata; and

(a) Conforming to relevant Technical Regulations.

Note: In circumstances where a WIGOS identifier is required for a station or platform to support a WMO or co-sponsored Programme and a Member is not able to issue a WIGOS identifier, the Secretary-General will work with the Member concerned to issue a WIGOS station identifier for that station or platform provided that its operator has committed to:

(a) Providing WIGOS metadata; and

(a) Conforming to relevant Technical Regulations.

See Attachment 2.1 – Structure of WIGOS Station Identifiers – in Annex 2 to Recommendation 16 (CBS-Ext.(2014)).

ANNEX XII
Annex to paragraph 3.1.17 of the general summary

RECOMMENDATIONS REGARDING THE IMPLEMENTATION OF OBSERVING SYSTEMS IN THE WMO REGIONS

The recommendations of the Implementation Coordination Team (ICT) on Integrated Observing Systems regarding the implementation of observing systems in the regions are as follows:

RA I

- Highest priority should be given by each Member in the Region to: (a) improve and restore the surface and upper-air observational capabilities of the RBSN/RBCN; and (b) improve data quality, regularity, and coverage of surface observations of the RBSN/RBCN. The high

cost of running upper-air stations was cited as a reason for the low number of upper-air stations which are operational. Enhanced support to the GUAN network should be included in the R-WIP as a high priority matter, and Members should allocate more resources towards this activity. Results of impact studies should be highlighted.

- Members are urged to comply fully with the global and regional coding procedures and data collection standards in accordance with procedures laid down in the *WMO Technical Regulations* and the *Manuals on the GOS*, *on Codes*, and *on the GTS* when operating the RBCN stations.
- Members are urged to continue their efforts to install ground weather radar stations for detecting precipitation, including heavy rain, hail and other severe weather phenomena, and to exchange on a bilateral or multi-lateral basis the meteorological information so obtained using the appropriate WMO code form (e.g., FM 94-IX Ext. BUFR).
- A mechanism should be developed and implemented for monitoring observational data quality and provide feedback, especially to those sites that are routinely providing observations marked as suspect on the monitoring.
- Members should be encouraged to participate in the AMDAR programme following the proposal made in the Regional Implementation Plan for AMDAR.

RA II

- Focus should be put on quality control procedures, metadata availability, integration of observational data and products, and improving traceability of the instruments in the Region.
- Active cooperation with all Members in the Region is needed on the issue of silent stations.
- The integration of observing systems especially, radar and ground-based lightning detection networks etc. is required.

RA III

- Density of the upper-air network should be increased; CBS encourages initiation of a regional project to address this issue.
- AMDAR should be further developed in the Region, and more countries should be engaged.
- More countries should be engaged in the regional and international real-time exchange of AWS data.
- Effort should be continued for exchanging at the national and regional level the surface weather radar data.
- Real-time monitoring of operational observational data should be promoted in the Region.
- The exchange of high-resolution upper-air observations should be improved.

RA IV

- Regional exchange of surface weather radars data should continue improving.
- Make effort to further develop and exploit web services for climate data, and promote international agreements for data sharing, as well as undertake efforts for surface data collection under the auspices of the International Surface Temperature Initiative in order to increase the daily periods of record for surface stations and the number of station records that can be routinely updated.
- AMDAR network in the Region should be optimized.

RA V

- Greater efforts by Members should be made in ensuring that their operational observing stations compile and transmit the climate-related messages according to existing WMO regulations.
- Continue and strengthen the integration of the RBSN & RBCN and other networks; and improve the data sustainability and availability performance of RBSN & RBCN to a satisfactory level to meet service requirements.
- Clarify the contribution of the Region in GCW.
- In order to protect present and future services provided by NMHSs for timely warning of impending natural and environmental disasters, accurate climate prediction and detailed understanding of the status of global water resources, it is essential that RA V Permanent Representatives ensure that national positions on radio frequency matters recognized the results of studies related to sharing of frequency bands allocated for meteorological and related environmental activities with other radiocommunication systems and especially that IMT/RLAN systems are made available to the wider radio frequency management community.

RA VI

- Organize and conduct a regional WIGOS Workshop to support the WIGOS implementation in RA VI at national level.
- Continue supporting the migration to Table Driven Code Forms.

Antarctica

- The need for a dedicated monitoring centre to pick up when AntON stations drop out and to give feedback on any issues that arise.
- For surface synoptic stations and upper-air stations, continued support is required for long-term monitoring of basic meteorological parameters.
- Attention should be given to the issue of surface CLIMAT stations, where: (i) AWS often only measure a limited range of parameters; and (ii) CLIMATs for AWS are often not available until data is downloaded and quality controlled (this may be after mid-month or more).

ANNEX XIII
Annex to paragraph 3.1.27 of the general summary

OBSERVING SYSTEMS NETWORK DESIGN PRINCIPLES

Members should follow the following principles when designing and evolving their observing system networks:

1. SERVING MANY APPLICATION AREAS

Observing networks should be designed to meet the requirements of multiple application areas within WMO and WMO co-sponsored Programmes.

2. MEETING USER REQUIREMENTS

Observing networks should be designed to address stated user requirements, in terms of the geophysical variables to be observed and the space-time resolution, uncertainty, timeliness and stability needed.

3. MEETING NATIONAL, REGIONAL AND GLOBAL REQUIREMENTS

Observing networks designed to meet national needs should also take into account the needs of the WMO at the regional and global levels.

4. DESIGNING APPROPRIATELY SPACED NETWORKS

Where high-level user requirements imply a need for spatial and temporal uniformity of observations, network design should also take account of other user requirements, such as the representativeness and usefulness of the observations.

5. DESIGNING COST-EFFECTIVE NETWORKS

Observing networks should be designed to make the most cost-effective use of available resources. This will include the use of composite observing networks.

6. ACHIEVING HOMOGENEITY IN OBSERVATIONAL DATA

Observing networks should be designed so that the level of homogeneity of the delivered observational data meets the needs of the intended applications.

7. DESIGNING THROUGH A TIERED APPROACH

Observing network design should use a tiered structure, through which information from reference observations of high quality can be transferred to and used to improve the quality and utility of other observations.

8. DESIGNING RELIABLE AND STABLE NETWORKS

Observing networks should be designed to be reliable and stable.

9. MAKING OBSERVATIONAL DATA AVAILABLE

Observing networks should be designed and should evolve in such a way as to ensure that the observations are made available to other WMO Members, at space-time resolutions and with a timeliness to meet the needs of regional and global applications.

10. PROVIDING INFORMATION SO THAT THE OBSERVATIONS CAN BE INTERPRETED

Observing networks should be designed and operated in such a way that the details and history of instruments, their environments and operating conditions, their data processing procedures and other factors pertinent to the understanding and interpretation of the observational data (i.e. metadata) are documented and treated with the same care as the data themselves.

11. ACHIEVING SUSTAINABLE NETWORKS

Improvements in sustained availability of observations should be promoted through the design and funding of networks that are sustainable in the long-term including, where appropriate, through the transition of research systems to operational status.

12. MANAGING CHANGE

The design of new observing networks and changes to existing networks should ensure adequate consistency, quality and continuity of observations across the transition from the old system to the new.

ANNEX XIV
Annex to paragraph 3.1.28 of the general summary

LIST OF TOPICS FOR NUMERICAL WEATHER PREDICTION IMPACT STUDIES RELEVANT TO THE EVOLUTION OF GLOBAL OBSERVING SYSTEMS

Short name: Full name	Science question
	Surface-based
S1MarinePs: Surface pressure over ocean	What density of surface pressure observations over ocean is needed to complement high-density surface wind observations from satellites
S2AMDAR: Coverage of AMDAR	What are the priorities for expansion of the AMDAR network? How does the impact vary over the globe? Provide guidance for AMDAR optimization.
S3Radar: Radar observations	What are the impacts of current radar observations, including radial winds and reflectivities?
S4Strat: In situ observations of the stratosphere	What network of in situ observations is needed in the stratosphere to complement current satellite observations (including radio occultation)? What about the tropics?
S5PBL: Observations of the PBL for regional and high-resolution NWP	What should be the focus of improvements for observations of the planetary boundary layer (PBL) in support of regional and high-resolution NWP? Which variables and what space-time resolution?
	Space-based
S6SatLand: Satellite sounding over land and ice	What is the impact of new developments in the assimilation of radiance data over land and sea ice?
S7Sounders: Impact of multiple satellite sounders	What benefits are found when data from more than one passive sounder are available from satellites in complementary orbits, e.g. the current unprecedented availability of four hyper-spectral sounders?
S8AMVs: Atmospheric Motion Vectors	Based on evidence from current AMV impacts, which AMV characteristics should be enhanced for the next generation of GEO satellites? What are the impacts of recent new types of AMVs such as MISR-AMV?
	General
S9UA: Regional upper-air network design studies	Upper-air network design studies such as those that have been performed for the European composite observing system (EUCOS) are required also in other Regions, especially in Region I where the basic networks are under pressure.
S10AdjEns: Application of adjoint and ensemble methods	What insights can be gained from adjoint and ensemble-based impact measures tailored for applications such as severe weather, aviation and energy? Specific impact metrics may be required.

Short name: Full name	Science question
S11Ocean: Impact in ocean-coupled assimilation	Which ocean observations are particularly important for NWP? Investigate the role of ocean observations in coupled atmosphere-ocean data assimilation with a focus on the 7–14 day range.
S12Land: Impact in land-coupled assimilation	Which land-surface observations are particularly important for NWP at all time ranges? Investigate the role of surface observations in coupled atmosphere-land data assimilation with a focus on the 7–14 day range.
S13 Time frequency	What is the required time frequency of observations? Consider AMDAR, GEO satellites and ground-based remote sensing observations (such as Doppler radar, wind profiler, ground based GNSS receivers) for regional and global NWP.
S14 Atmospheric composition	Study observation impact in atmospheric composition and air quality applications.
S15 OSSEs	Observing system simulation experiments are encouraged in support of satellite system design criteria such as orbit optimization for GPS-RO satellites, or configurations for hypersperspectral IR sounders on geostationary orbit.

ANNEX XV
Annex to paragraph 3.2.25 of the general summary

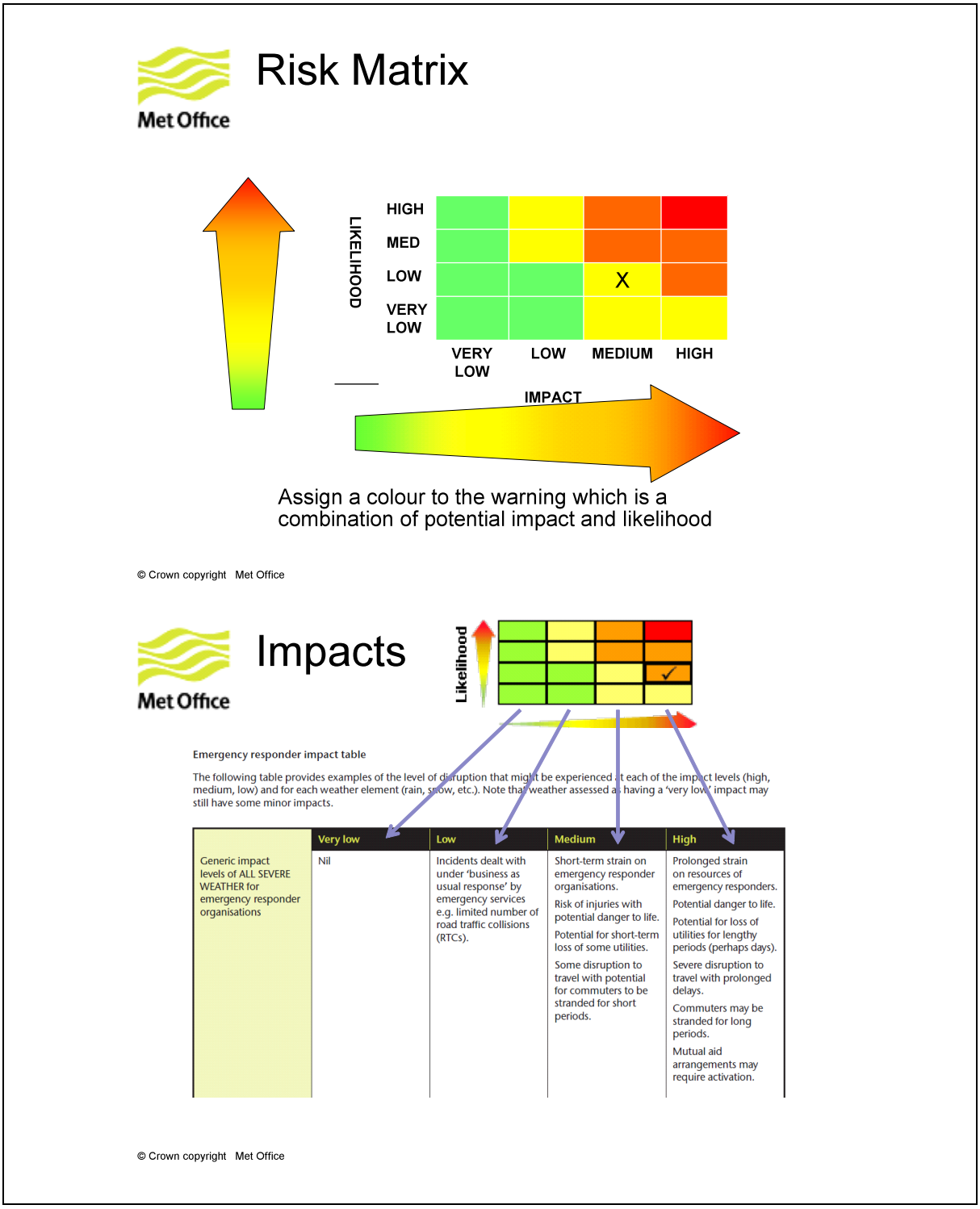
TERMS OF REFERENCE OF THE IMPLEMENTATION COORDINATION TEAM ON INFORMATION SYSTEMS AND SERVICES

Add the following item to the Terms of Reference of ICT-ISS:

(g) To develop and maintain a strategic plan for the development of the WIS over a ten year forward looking period.

ANNEX XVI
Annex to paragraph 4.3.5 of the general summary

EXAMPLE OF A RISK MATRIX



The colours have the following basic structure – Green: No severe hydrometeorological hazard is expected; Yellow: Be aware; Orange: Be prepared; and Red: Take action.

Figure 1. Risk Matrix – A colour is assigned to a warning based on the combination of potential impact and likelihood (Source: Met Office-UK)

ANNEX XVII
Annex to paragraph 4.4.2 of the general summary

2-, 6- AND 10-YEARS' VISION FOR THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM

Expert Team	Top Level Objectives	Current Status	2-Year	6-Year	10-Year	Contributions to GFCS, DRR, Capacity Development, WIGOS/WIS and Aviation Meteorology	Engagement with Organizations dealing Agriculture, Health, Water and DRR
Operational Weather Forecasting Process and Support (OWFPS) and Steering Group of the Severe Weather Forecasting Demons-tration Project (SG-SWFDP)	Sustain and enhance quality and reliability of operational forecasting services with the latest development and findings: – guidance on access to high-resolution NWP – standard procedure for surface verification – use of NWP for hazard risk manage-ment	Many advanced centres applying global and regional NWP, some with integrated EPS, and with sophisticated post- processing and visualization systems. However, many NMHSs still lack access to high quality NWP data. Cascading forecast process successfully demonstrated in three SWFDP projects and sustainably established in one region, with two more projects underway and other two in development.	Established procedures for verification of surface weather. Guidance on access to high-resolution LAM NWP Updated Manual for DPFS defines Quality Management framework for maintenance and sustainability of DPFS SWFDP Project Office established and staffed.	Established SWFDP service in further areas providing wider access to NWP products and forecasts guidance. Verification of surface weather implemented. Quality Management system for DPFS implemented. Increased propagation of NWP data into impact models to deliver timely warning of high-impact weather including planning and recovery in DRR (e.g. hydrology, storm surge, wave/swell)	Core set of high-quality NWP including EPS and VSRF systems used by all NMHSs. Consolidate SWFDP into global sustainable operational services through enhanced cascading forecast process. Wide availability of improved convection-allowing model forecasts.	All NMHSs have capability to provide hydro–meteorological forecasting and warning services in support of DRR – capacity development improved aviation services from convection allowing models. Strengthening of NMHS capabilities and reputation through SWFDP improves return of observations through WIS/WIGOS.	Extend the range of targeted application to broaden the benefits of SWFDP to other user sectors in society. Working with other organizations for risk reduction and post-event disaster relief (e.g. UN Agencies, NGOs, Humanitarian Organizations for DRR)
OWFPS	Space Weather	A few centres providing observations and forecasts for national purposes. Some bilateral collaborations.		Develop plan for establishing RSMC for Space Weather specialization.	Established RSMCs with Space Weather specialization.	NMHSs have access to advice on Space Weather for DRR through the WIS.	
Operational Prediction from Sub-seasonal to Longer-time Scales (OPSLS)	Enhanced GPC and LC products (Seasonal)	Network of 12 GPCs and two facilitating Lead Centres providing seasonal forecast guidance to RCCs and NMHSs. Collaboration with CCI includes through Task Team on the Global Seasonal Climate Update (GSCU), the joint CCI/CBS Expert Team on Regional Climate Centres (RCCs) and the CCI ET on the CSIS – each of which shares membership with ET-OPSLS.	Review user needs in context of developing GFCS, including training needs, in collaboration with CCI	Enhanced set of GPC products to meet identified user needs; improved understand and take-up of products including support for Humanitarian Organizations	Dynamical seasonal forecast products are well understood by members and integrated in national and regional services, and informing decisions related to water, health, agriculture and food security and DRR.	Capacity development of RCCs and NMHSs; improved information on DRR related to climate variability available on WIS.	Contributions to users through the RCOFS (Regional Climate Outlook Forums). Support for Humanitarian Organizations for DRR.

Expert Team	Top Level Objectives	Current Status	2-Year	6-Year	10-Year	Contributions to GFCS, DRR, Capacity Development, WIGOS/WIS and Aviation Meteorology	Engagement with Organizations dealing Agriculture, Health, Water and DRR
OPSLS	Sub-seasonal forecast	Centres making forecasts but no formal WMO structure for delivery.	Collaborate with WWRP & WCRP to scope an operational framework	Operational framework implemented through a network of centres providing multi-model sub-seasonal forecasts to user requirements	Dynamical sub-seasonal forecast products are well understood by members and used in national and regional services, and informing decisions related to water, health, agriculture and food security and DRR.	Capacity development of RCCs and NMHSs; improved information on DRR related to climate variability available on WIS.	
OPSLS	Multi-annual to decadal timescale forecasts	Research centres making decadal forecasts but no formal WMO structure for delivery to RCCs and NMHSs. Experimental exchange of multiannual to decadal forecasts demonstrated. Climate change projections are available through e.g. WRCP CMIP5.	Capacity for operational exchange of multi-annual to decadal forecasts demonstrated in collaboration with CCl. Centres for operational multi-annual to decadal forecasts identified.	CBS centres for operational multi-annual to decadal forecasts defined and providing prediction guidance to RCCs and NMHSs according to a developing understanding of prediction skill and user needs. CBS contributions to longer-than-decadal projections (e.g. climate change projections) defined.	Decadal prediction services enhanced with wider application by users. CBS contributions to longer-than-decadal projections implemented.	Capacity development of RCCs and NMHSs; improved information on DRR related to climate variability available on WIS.	
Emergency Response Activities (ERA)	New ERA Products	Established set of products provided to cover nuclear incidents in all WMO Regions; online training materials provided.		Time-of-arrival products added to ERA products set. All products available in shapefile format		Improved presentation of ERA products through WIS.	IAEA, WHO
ERA	Non-nuclear capability	Existing RSMCs can respond on a best endeavours basis but no structured procedures in place.	Procedures agreed & demonstrated in test	ERA Service for major non-nuclear incidents operational.	ERA for non-nuclear hazards to reach the same level of operational maturity as nuclear ERA. NMHSs capable of addressing small- scale non-nuclear events in their own countries	DRR	IAEA
ERA	Radioactive clouds in the atmosphere for Aviation	Existing products are not suitable for this application.		Test demonstration of potential capability.	ERA guidance products for radioactive clouds in the atmosphere to meet the needs of aviation and ATC	Aviation Met	ICAO

APPENDIX

1. Officers of the session

Frederick R. BRANSKI	President
Sue BARRELL (Ms)	Vice-President

2. Members of CBS

Argentina

Mario GARCÍA	Principal Delegate
Julián DUNAYEVICH	Delegate

Australia

Anthony REA	Alternate
Russell STRINGER	Delegate

Azerbaijan

Mehman MAMMADOV	Delegate

Belgium

Liliane FRAPPEZ (Ms)	Principal Delegate

Botswana

Radithupa RADITHUPA	Delegate

Brazil

José Mauro DE REZENDE	Principal Delegate
Alaor Moacyr DALL' ANTONIA	Alternate
José Arimatea DE SOUZA BRITO	Delegate
Waldenio GAMBI DE ALMEIDA	Delegate
Cleber SOUZA CORREA	Delegate

British Caribbean Territories

Tyrone W. SUTHERLAND	Principal Delegate

Burundi

Ruben BARAKIZA	Principal Delegate

Canada

Michel JEAN	Principal Delegate
Michael MANORE	Alternate
Peter SILVA	Delegate

Chile

Guillermo NAVARRO	Principal Delegate
Gaston TORRES	Delegate

China

MEIYAN JIAO (Ms)	Principal Delegate
MINGMEI LI	Alternate
YONGQING CHEN	Delegate
CUIYING TIAN	Delegate

Costa Rica

Maria SUAREZ (Ms)	Principal Delegate

Croatia

Ivan CACIC	Principal Delegate
Kreso PANDZIC	Delegate

Cuba

Moisés Luciano AMARO ARGÜES	Principal Delegate

Curaçao and Sint Maarten

Albert MARTIS	Principal Delegate

Czech Republic

Eva CERVENÁ (Ms)	Principal Delegate

Denmark

Ellen Vaarby LAURSEN (Ms)	Principal Delegate

Ecuador

Manuel CARVAJAS	Principal Delegate
Lucia Jacqueline DE LA CRUZ ARCE (Ms)	Alternate

Egypt

Amal GBR HANAFY (Ms)	Principal Delegate
Nadia HASSAN MOHAMED (Ms)	Alternate

Finland

Lasse LATVA	Principal Delegate

France

Matteo DELL'ACQUA	Principal Delegate
Loïc LE GALLOU	Alternate

Germany

Jochen DIBBERN	Principal Delegate
Dieter SCHRÖDER	Alternate

Guatemala

Paris RIVERA RAMOS	Principal Delegate

Honduras

Francisco J. ARGEÑAL	Principal Delegate

Hong Kong, China

Sai-tick CHAN	Principal Delegate

India

Rajesh MALI	Principal Delegate

Indonesia

Edward TRIHADI	Principal Delegate
Bambang WIJAYANTO	Alternate

Iran, Islamic Republic of

Mina JABBARI (Ms)	Delegate
Farah MOHAMMADI (Ms)	Delegate

Ireland

Sarah O'REILLY (Ms)	Principal Delegate
Gerald FLEMING	Delegate

Italy

Adriano RASPANTI	Principal Delegate
Antonio VOCINO	Delegate

Japan

Masanori OBAYASHI	Principal Delegate
Yuki HONDA	Alternate
Jitsuko HASEGAWA (Ms)	Delegate
Eiji TOYODA	Delegate
Kenji TSUNODA	Delegate

Kenya

James KONGOTI	Principal Delegate
Peter S. MASIKA	Delegate

Netherlands

Jan Willem NOTEBOOM	Principal Delegate

New Zealand

Peter KREFT	Principal Delegate
James LUNNY	Alternate

Norway

Cecilie STENERSEN (Ms)	Principal Delegate
Jan Ivar PLADSEN	Alternate

Oman

Said Abdullah AL HARTHI	Principal Delegate
Hamid Ahmed AL BRASHDI	Delegate
Musallam Ali AL MASHANI	Delegate

Paraguay

Julian BAEZ BENITEZ	Principal Delegate
Noe MONTENEGRO	Delegate
Oscar RODRIGEZ	Delegate
Carlos R. SALINAS	Delegate
Jorge A. SANCHEZ	Delegate

Peru

Jorge Dante CHIRA LA ROSA	Principal Delegate

Republic of Korea

Heejin IN	Principal Delegate
Chulwoon CHOI	Delegate
Dongil SEO	Delegate

Russian Federation

Roman VILFAND	Principal Delegate
Dzhalil AKHTYMOV	Delegate
Nikolai MIKHAILOV	Delegate

Slovakia

Branislav CHVILA	Principal Delegate

Spain

Guillermo GARCÍA YÁÑEZ	Principal Delegate
Jorge Tamayo CARMONA	Delegate

Sweden

Stefan NILSSON	Principal Delegate

Switzerland

Estelle GRUETER (Ms)	Principal Delegate

Trinidad and Tobago

Marlon NOEL	Principal Delegate

Turkey

Ömer Hüdai ALBAYRAK	Delegate

Uganda

Michael S.Z. NKALUBO	Principal Delegate

United Kingdom of Great Britain and Northern Ireland

Stuart GOLDSTRAW	Principal Delegate
Bruce TRUSCOTT	Alternate
Ken MYLNE	Delegate
Fiona TOVEY (Ms)	Delegate

United States of America

Laura FURGIONE (Ms)	Principal Delegate
William C. BOLHOFER	Alternate
John D. MURPHY	Alternate
Fredrick R. BRANSKI	Delegate
Elliott JACKS	Delegate
Kelly B. SPONBERG	Delegate

Zimbabwe

Dennis KAPASO	Delegate

3. Representatives of international organizations (observers)

Centro Internacional para la Investigación del Fenómeno de El Niño (CIIFEN)

Rodney MARTINEZ

European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)

Simon ELLIOTT	Observer
Lothar WOLF	Observer

International Civil Aviation Organization (ICAO)

Neil HALSEY	Observer

4. Invited experts

Mr Juan Carlos FALLAS-SOJO	President of RA IV
Mr Enrique GARRIDO	Observer
Mr Bertrand CALPINI	President of CIMO

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