World Meteorological Organization

Aircraft-Based Observations Programme

Strategy and Implementation Plan to 2025 Including Development and Expansion of AMDAR

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&
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Scope

This document describes the strategy and plan for implementation of the enhanced and expanded WMO aircraft-based observing system as a component of the WMO Integrated Global Observing System and the World Weather Watch Global Observing System (GOS). While this includes the strategy and plan for enhancement and coverage expansion of the WMO AMDAR observing system as the primary aircraft-based observing system, it also incorporates the strategy for development and further access to observations from regional airlines (RA) and smaller general aviation (GA) aircraft operating out of regional airports and for increased access to meteorological data generated by ICAO systems that support aviation and airline flight operations. Enhancement through the wider measurement of parameters such as water vapour, atmospheric turbulence and aircraft icing is also incorporated.

The strategy is relevant to WMO Members and partner organizations that currently, or will in the future operate aircraft-based observing systems or contribute to the generation and delivery of data from such systems through the WMO Information System (WIS).

The implementation of the strategy will be overseen by the WMO Commission for Basic Systems (CBS) and under the responsibility of its Expert-Team on Aircraft-Based Observations (ET-ABO) as well as the Commission for Instruments and Methods of Observation (CIMO) under the responsibility of its Task-Team on Aircraft-Based Observations (TT-AO), relying on the resource input of WMO Members and partner organizations and coordination through the WMO Regional Associations. The programmatic and governance structure for the teams responsible for this development will be referred to as the Aircraft-Based Observations Programme (ABOP)[1].

The strategy will focus in detail on the shorter-term, 5-year evolution of the aircraft-based observing system and, in line with the CBS planning process, extend to longer-term aims and objectives towards 2025 (see Annex 1).

Further background information on the aircraft-based observing system and the AMDAR system is available at: http://www.wmo.int/pages/prog/www/GOS/ABO/index_en.html

Requirements, Justification, Aims and Objectives

The justification for the requirement to expand and enhance aircraft-based observing system coverage and capability is primarily based on the CBS Implementation Plan for the Evolution of the Global Observing System[2] (EGOS-IP), which determines and specifies requirements, strategy and actions for the evolution of WMO observing systems. The EGOS-IP is founded on the WMO Rolling Review of Requirements (RRR) process, which undertakes: an assessment of data user and applications requirements; assessment of observing system impacts and

1 http://www.wmo.int/pages/prog/www/GOS/ABO/ABOWorkTeams.html
2 http://www.wmo.int/pages/prog/www/OSY/gos-vision.html#egos-ip

capability; identification of observing system gaps and potential for improvement; and, the specification of national, regional and global actions to implement the evolution and improvement process.

The benefits of aircraft-based observations (ABO) to various meteorological data users and application areas, particularly to and by Numerical Weather Prediction (NWP) systems, have been well demonstrated and utilized within the RRR process to provide the basis and justification for the relevant actions within the EGOS-IP.

The global actions relevant to aircraft-based observing systems, which essentially form the basis for the aims and objectives for the development of these systems are extracted from the EGOS-IP and presented in Annex 2 to this document. These actions are summarized as:

1. G19: Improve AMDAR Coverage - especially over and within RA I and RA III.
2. G20: Extend coverage of existing programmes outside national boundaries and extend optimization capability.
3. G21: Work towards extension of AMDAR into aviation standards and systems (avionics and airframes)
4. G22: Validation and implementation of water vapour measurement
5. G23: Implementation of turbulence and icing capability
6. G24: Extend AMDAR to aircraft operating at the regional scale and regional airports.

Taking into account the requirement to support the technical development and also the development and standardization of the operational framework for observing system and data quality management, a set of aims and objectives were developed under the Aircraft-Based Observations Programme in the form of the Core Activities given below.

WMO Aircraft-based Observing System Core Activities

1 Enhancement of AMDAR Observing System Coverage.

1.1 Extend global AMDAR coverage, particularly over upper air data sparse and developing areas.
1.2 Address the requirement for national, regional and global optimization
1.3 Extend operational and future AMDAR Programmes to regional airlines and GA aircraft with coverage of regional airports.

2 Extension of the AMDAR Observing System.

2.1 Implement water vapour measurement.
2.2 Implement turbulence reporting.
2.3 Implement icing indication.

2.4 Consider and analyse requirements for other measurements and sensors as candidates for addition to the AMDAR system, e.g including volcanic ash and other aerosol detection.

3 Research and Development of New Aircraft Observation Technologies.

3.1 Manage risks and opportunities to the AMDAR Observing System associated with new and developing technologies in avionics, communications and metrology.

4 Development and Maintenance of the Aircraft-based Observing System Quality Management System.

4.1 Implement a Quality Management Framework for AMDAR that incorporates standardization and harmonization across national and regional programmes, taking into account:

1) Data management;
2) Metadata management;
3) Quality control for metrological systems;
4) Systems performance and data quality control, monitoring and evaluation.

4.2 Develop a Global Aircraft Observations Data Management Framework.
4.3 Standardize AMDAR software function across avionics systems and optional sensors (e.g. water vapour) across aircraft.
4.4 Manage the data processing and quality assurance for other sources of aircraft data transmitted on the GTS including data provided through ICAO.

5 Aircraft Observing System Training and Outreach.

5.1 Develop methods and material for promoting the Aircraft-Based Observations Programme and the AMDAR observing system.
5.2 Conduct training and outreach activities in support of Core Activities.

6 Management and administration of the Aircraft-Based Observations Programme

6.1 Conduct meetings of members and stakeholders.
6.2 Coordinate planning activities.
6.3 Monitor and evaluate the Aircraft-Based Observations Programme.

The strategy and the implementation plan for the ABOP will be focused on implementing the EGOS-IP actions through the undertaking of the above Core Activities.

Implementation Strategy & Plans

General Programmatic Strategy & Principles

1. The strategy for aircraft-based observations (ABO) will be developed by the ABOP based on undertaking and accomplishing the actions of the CBS EGOS-IP.
2. Primary responsibility for ABO system implementation and operation will lie with WMO Member NMHSs in collaboration with Regional Associations and partner airlines and organizations.
3. Fundamental to the long-term strategy for AMDAR is to seek to ensure that all elements of the programme are or become embedded within the relevant aviation engineering, communications and manufacturing designs, protocols and standards. This includes AMDAR software applications and sensor systems.
4. The strategy for development of AMDAR and other ABO systems and the 3rd party observational data that are derived from them, are very reliant upon the continued and expanded contribution and cooperation of the aviation industry and, in particular, partner airlines that provide the aircraft platforms, avionics systems and onboard sensors. For this reason, significant resources must be dedicated to the aspects of the programme that strengthen and develop the relationships, agreements, avionic standards and data exchange protocols that are vital for its ongoing operation.
5. It is critical that ABO development and expansion is undertaken with a view to the building and maintenance of an aircraft-based observing system that is both stable over the long-term and meets requirements (WMO RRR) for data quality. Therefore, the ABOP must plan for and dedicate resources to both the development of the quality management system for ABO (as a component system of WIGOS) and the integration and maintenance of the system within the wider aviation infrastructure.
6. Where possible, Regional Associations should endeavour to promote and coordinate the implementation of ABO systems so as to take advantage of efficiencies associated with regional or sub-regional collaboration in the requirements for development and operation of data processing and optimization system infrastructure.
7. Members should endeavour to develop programmes in accordance with WMO and WIGOS manuals, guides and standards.
8. As an observing system that is strongly reliant on 3rd party participation, collaboration and cooperation:
    a. Outreach and promotional activities must be a core and ongoing component of the ABOP strategy; and.
    b. The ABOP must continue to interact with relevant areas of the aviation industry to ensure that a knowledge of current and likely future developments in avionics and communication standards relevant to ABO systems is maintained.

1 Enhancement of AMDAR Observing System Coverage

1.1 Extend global AMDAR coverage, particularly over upper air data sparse and developing areas

Background

Despite the fact that the existing AMDAR Programmes together currently produce more than 400,000 observations per day, the geographic distribution is not optimal. Upper-air data-sparse areas exist in several parts of the world and first priority should be given to expanding the observations in RA I and RA III where this problem is most pronounced.

A consultants' study[3] has identified commercial airlines with great potential for providing AMDAR observations in all RAs.

Well established regional or national AMDAR Programmes may provide support and demonstrate their best practices e.g. sharing their experience and expertise by participation in regional workshops or by direct interaction with new programmes. Special emphasis will be placed on those Regional Associations or NMHSs that respond to the challenge of establishing an AMDAR programme or further developing an existing programme.

Given the 50% only capacity of the scientific officer responsible for ABOP coordination within the WMO Secretariat, an AMDAR Development Officer (ADO) should be employed to work with RAs and NMHSs to: 1) Provide ongoing, dedicated development and technical support; 2) Assist putting in place RA AMDAR Implementation Plans; and 3) Provide assistance to develop business cases to motivate airline cooperation and other plans as needed.

Strategy

- Use experience and best practice of regional and national AMDAR Programme as a model for global expansion: e.g E-AMDAR and US-AMDAR - The ideal AMDAR system incorporates a regional data processing centre with data optimization functionality and is depicted by the data management framework diagram shown in Annex 3.
- The ABOP will attempt to develop and nurture a regional approach to ABO and AMDAR Programme implementation through the WMO Regional Associations but also provide requested support directly to those individual NMHSs that have demonstrated capability and drive to establish AMDAR programmes.
- ET-ABO, SO/ARO and ADO will work towards the development on AMDAR Regional Implementation Plans (A-RIPs) that will be incorporated into the Regional WIGOS Implementation Plans (R-WIPs).
- Through Activity 4.3, (Standardize AMDAR software function across avionics systems and optional sensors (e.g. water vapour) across aircraft), seek to ensure that AMDAR programmes and their partner airlines have easy access to standard off-the-shelf AMDAR software applications from avionics vendors or other sources.
- The ABOP will investigate and take advantage of new & additional opportunities for derivation of aircraft-based observations from ICAO systems, currently including ADS-C, ADS-B and Mode S.

3 AMDAR Coverage & Targeting for Future Airline Recruitment

- Through the Training and Outreach activity, the ABOP will hold workshops and training seminars and develop materials that promote, encourage and enable national and regional programme development and expansion.

Recent Activities

- Study on coverage and target airlines was carried out by consultants. Report is available at: http://www.wmo.int/pages/prog/www/GOS/ABO/AMDAR/resources/AMDAR_Coverage_Recruitment_Study.html
- An AMDAR Development Officer, ADO was contracted for 12 months (50% capacity) as consultant and started working 1 July 2013.

Medium-term Implementation Plan [5 years]

Task (Priority 1-highest)	Sub-Task	Commence	Complete	Responsibility
1.1.1 Develop global strategy and implementation planning documents **(1)**	1.1.1.a Review and complete final draft and obtain approval to publish.	Sep 2013	Q4 2013	SO/ARO, ADO, C/ET-ABO
	1.1.1.b Review and complete final draft and obtain approval to publish.	Sep 2013	Nov 2013	SO/ARO, ADO, ET-ABO
1.1.2 Develop regional implementation planning template **(1)**	1.1.2.a Complete initial draft for review by ET-ABO	August 2013	9 Sep 2013	SO/ARO, ADO, C/ET-ABO
	1.1.2.b Complete final version	Sep 2013	1 Oct 2013	SO/ARO, ADO, C/ET-ABO
1.1.3 Develop regional implementation plans **(1)**	1.1.3.a Establish leadership expert groups in each WMO Region	Sep 2013	Dec 2013	ET-ABO(Region Leads), Region I - VI supported by SO/ARO, ADO
	1.1.3.b Develop 1st drafts of implementation plans for each WMO Region	Sep 2013	Dec 2013	Region I - VI Leads supported by SO/ARO, ADO
	1.1.3.c Attend upcoming RA Meetings over coming 3 years and promote A-RIP as a WIGOS activity.	Jan 2013	Ongoing	WMO Secretariat, ET-ABO
1.1.4. Develop guidance material for NMHS for programme initiation **(1)**		Q4 2013	Q2 2014	SO/ARO, ADO, ET-ABO, TT-AO
1.1.5 Compile and analyse information about the benefits of AMDAR **(1)**	1.1.5.a .Complete ABO Benefits to Meteorology and Aviation document	Q2 2013	Q4 2013	SO/ARO, ADO, C/ET-ABO

Task (Priority 1-highest)	Sub-Task	Commence	Complete	Responsibility
	1.1.5.b .Complete AMDAR Benefits to Aviation document	Q4 2013	Q2 2014	SO/ARO, ADO, C/ET-ABO
1.1.6. Optimise and extend existing programme coverage **(1)**	1.1.6.a. Investigate international approach to AMDAR data coverage enhancement from existing programmes.	Q1 2013	Q2 2014	ET-ABO , Operational Programme FPs
	1.1.6.b. Work with Panasonic Avionics and FLYHT to investigate provision of required data only through elimination of redundant data by optimisation.	Q1 2014	Q3 2014	SO/ARO, C/TT-AO
1.1.7. Investigate the possibility to collect, and increase, observations over polar regions **(3)**		Q3 2014	Q2 2015	ET-ABO
1.1.8. Develop proposals for international development projects for ABO and seek funding. **(2)**		Q1 2013	Ongoing	SO/ARO, C/ET-ABO

Activity Notes

1.1.2.b The final version will be distributed to the contact persons in each WMO Region.

1.1.3.a Each leadership group should include the regional contact persons and key experts.

1.1.5 The cost/benefit information can support RAs/NMHSs in convincing airlines of the benefit of participating in AMDAR programmes. The benefit of the use of WVSS-II is in Activity 2.1.3.

1.2 Address the requirement for national, regional and global optimization

Background

AMDAR Programmes have to pay for all or a major part of the observations they acquire from cooperating airlines. If observation frequency is high redundant data may be produced at high cost to the AMDAR Programme. A well designed optimizer makes it possible to define how, where and when observations should be made by the aircraft, thus reducing the operational costs.

Optimization allows a convenient way to rapidly and easily adjust programme coverage and can enhance global coverage by allowing data to be generated outside of national and regional

programme coverage boundaries in support of the global programme. This activity, in conjunction with appropriate agreements and cost recovery activity should be further developed. Combining wider use of optimization and the AMDAR activation of international aircraft fleets will support coverage extension of the global AMDAR programme.

Optimization also allows the targeting of observations for weather-related issues and perhaps even for seasonal cycles. This benefit of optimization should be further developed and promoted.

Strategy

- Use the specifications and experience of existing AMDAR Programmes with optimization systems to assist new programmes to develop or acquire optimization systems.
- Explore what services Data Service Providers (DSPs) e.g ARINC and SITA can offer for optimization.
-
- Work towards development of a standard specification of functional requirements for optimization.
- Work towards developing a better structure and possibly an international (WMO) administration for provision of “Supplementary AMDAR Data” - additional data produced by AMDAR programmes under international agreements that support global coverage extension.

Recent Activities

- The Panel and the WMO Secretariat have been liaising with SITA regarding the development of an AMDAR data processing system that might eventually incorporate an optimization system. This would suit both a national and regional approach to programme management.
- The USA has been collaborating with ARINC re an optimization capability for the USA AMDAR programme.

Medium-term Implementation Plan [5 years]

Task (Priority 1-highest)	Sub-Task	Commence	Complete	Responsibility
1.2.1 Develop a standard specification for AMDAR Optimization System **(1)**		Q3 2013	Q4 2014	TT-AO
1.2.2 Work with corporate Data Service Providers to enable data optimization services to be available to NMHSs. **(2)**		Q1 2014	Q3 2014	SO/ARO, C/TT-AO
1.2.3 Develop an optimization capability for the US-AMDAR Programme. **(1)**	1.2.3.a. Implement the standard for AMDAR Data Optimization System in the US-AMDAR Programme	Q1 2015	Q4 2015	US FP

1.3 Extend AMDAR Programme to Regional Airlines and GA aircraft for coverage of regional airports

Background

What can be achieved in terms of the production of regular vertical profiles of temperature and wind will also depend on the location of airports used by commercial airlines. In some areas there are very long distances between these airports. It is, therefore, of interest to establish cooperation with regional and general aviation operators that operate at regional airports. In this way the observation network can be improved, particularly for vertical profiles.

Strategy

- ABOP will continue to investigate and take advantage of new & additional opportunities for derivation of aircraft-based observations from Regional Airlines and General Aviation (GA) aircraft and regional airports, including through interaction, as needed, with relevant 3rd party data providers. This currently includes Panasonic Avionics and FLYHT, which work directly with smaller regional airlines and operators of GA aircraft putting in place the TAMDAR and AFIRS avionics systems respectively, which are capable of providing aircraft-based observations similar to AMDAR.

Recent Activities

- Panasonic Avionics is now a member of HMEI and has Associate Membership to ET-ABO
- Panasonic Avionics made presentations to the AMDAR Panel Management Group, the AMDAR Panel and ET-ABO with a view to collaboration being extended.
- A representative from FLYHT attended the ET-ABO 1 Session and provided a presentation on potential collaboration and provision of ABO data.

Medium-term Implementation Plan [5 years]

Task (Priority 1-highest)	Sub-Task	Commence	Complete	Responsibility
1.3.1 Monitor the results of TAMDAR impact studies undertaken by UKMO and EUMETNET **(1)**		Q3 2013	Q4 2014	TT-AO
1.3.2 Collaborate with 3rd party ABO data providers on provision of data to WMO Members **(1)**		Q3 2013	Ongoing	ET-ABO

2 Extension of the AMDAR System

2.1 Implement water vapour sensing measurement

Background

As humidity is an essential parameter for prediction of several weather phenomena it is important to include humidity observations in aircraft-based observations programmes. Extensive testing of the WVSS-II equipment in climate chambers, on research aircraft and on commercial aircraft was carried out by the AMDAR programmes in Europe and the USA and was considered by the Panel to be the only currently available sensor that adequately meets scientific and AMDAR operational performance standards. Evaluation of the operational performance of alternative humidity sensors will continue with documented results.

The US-AMDAR programme currently has the WVSS-II sensor operationally installed on more than 112 aircraft and the E-AMDAR programme is in the process of installing the equipment on 9 aircraft. Other programmes should be encouraged and assisted to develop and implement plans (in line with the actions of the EGOS-IP). However the chief hurdles to overcome are 1) the considerable cost of aircraft type certification and integration; and, 2) the reluctance or unwillingness by some airlines to install the equipment due to issues such as: lack of strong business case justification, lack of technical capability, lack of resources, leasing rather than ownership of the aircraft and “make-good” issues. It is therefore desirable that aircraft would have the equipment installed as a standard or optional deliverable from the factory floor or by retrofit on request. At least one aircraft manufacturer indicated that they would be willing to supply this as optional equipment but only if there is a demonstrable interest by airlines for future orders. The costs and cost-sharing between NMHSs and airlines of installation and maintenance are significant issues and so development of cost/benefits material for WVSS-II integration and operation is and will be crucial.

The AMDAR Panel reviewed an initial draft of an implementation plan for WVSS-II and water vapour measurement at its meeting in 2012 and this work is being continued under the CIMO Task Team on Aircraft-Based Observations (TT-AO). That document will form the detailed implementation plan for WVSS-II implementation.

The other currently known source of humidity data from the aircraft platform is via the Panasonic Avionics (formerly AirDat) TAMDAR system. Data has previously been utilized and assessed for impact by NOAA through the Great Lakes Field Experiment (GLFE) that took place during the last decade. EUMETNET currently has an agreement with Panasonic Avionics to receive and use TAMDAR data for an impact assessment of the data over the USA region and other areas

as it becomes available via the extension of the TAMDAR network. The ABOP will continue to assess TAMDAR as an additional source of ABO data.

Strategy

- Continue validation of WVSS-II and document the data impacts and the benefits of water vapour measurement as a component of ABO and AMDAR.
- Implement WVSS in current programmes.
- Work towards integration of WVSS as a standard equipment on aircraft platforms.
- Evaluate of TAMDAR (UK and ECMWF data impact studies)

Recent activities:

- Testing of WVSS-II in Europe on FAAM (UK) and DENCHAR (Germany) research aircraft (2 sensors on each aircraft): Report from FAAM at AMDAR Projects & Collaboration Site.
- WMO Special Service Agreement (SSA) with University of Wisconsin to complete study on impacts of AMDAR and WVSS - II, two papers to be delivered in Q4 2013

Medium-term Implementation Plan [5 years]

Task (Priority)	Sub-Task	Commence	Complete	Responsibility
2.1.1 Investigate development of joint project with ICAO for widespread implementation of AMDAR including humidity sensors in commercial aircraft **(1)**		Q1 2012	TBD	SO/ARO, ADO, C/ET-ABO
2.1.2. Continue aircraft testing and validation of WVSS-II **(1)**	2.1.2.a Monitor and report on testing of WVSS-II systems on test aircraft (FAAM and DENCHAR)	2011	Ongoing	TT-AO
	2.1.2 b Produce one or more CIMO IOM reports providing validation status of WVSS-II	Q2 2013	Q1 2014	TT-AO
2.1.3. Complete and publish WVSS -II data Impact papers **(1)**		Q1 2012	Q4 2013	SO/ARO Ralph Petersen
2.1.4. Develop a plan for inter-comparison of AMDAR and WVSS-II with other measurement systems **(1)**		Q3 2013	Q2 2014	TT-AO
2.1.5. Complete Implementation Plans for WVSS-II **(1)**		Commenced	Q4 2013	TT-AO

Activity Notes

2.1.1 A joint WMO-ICAO Project has been proposed in support of the widespread implementation of AMDAR, including humidity sensors, in commercial aircraft.

2.1.4 The purpose of the inter-comparison is to compare with other humidity instruments (e.g. radiosonde) and demonstrate that the WVSS-II sensor meets scientific and data user requirements.

2.1.5 The plan will have two aspects. The first concerns implementation in existing AMDAR Programmes through retrofit and the other will encompass the equipping of new aircraft with the WVSS-II sensor during the factory manufacture and fitting process.

2.2 Implement turbulence reporting

Background

Turbulence causes not only discomfort to passengers and airline crew but personal injuries do occur and damages to aircraft and equipment is not rare. Therefore, reporting and improved forecasting of turbulence is of interest in the area of NMHS services to aviation and, critically, to airline operations and safety, thus strengthening the case for AMDAR participation. Turbulence is difficult to predict in NWP partly because there are too few reliable observations. Pilots usually make reports during flights when turbulence is encountered but the quantification is subjective and data are difficult to use in NWP.

Systematic and quantified observations of turbulence and reporting together with other aircraft-based observations will make it possible to predict turbulence as a service to airlines both for route planning and for in-flight advice and warning. Very good progress in this field has been made in the USA.

The Eddy Dissipation Rate (EDR) is the ICAO standard metric for turbulence measurement and will become the preferred standard for AMDAR. The new AMDAR Onboard Software Functional Requirements Specification (AOSFRS) specifies the algorithm for routine and event based reporting of EDR. The ABOP has established key contacts and team membership from the FAA and NCAR that can assist in developing and implementing a strategy for EDR measurement and data utilization. Another metric of turbulence is the Derived Equivalent Vertical Gust - DEVG – and is reported by some operational AMDAR programmes.

Strategy

- Follow and participate as required in the FAA/NCAR EDR developments:
    - EDR Standardization Project
    - Operational trials and development and testing turbulence forecast products
- Encourage and coordinate implementation of EDR outside of USA initially focussing on development in Europe
- Undertake and coordinate pilot project(s) on EDR implementation in E-AMDAR
- Interact with NWP on data utilisation.
- Interact with ICAO and other aviation organizations to determine their requirements for turbulence warnings and other aviation applications.

Recent Activities

- Turbulence workshop in Boulder, November 2012 with NCAR

- Turbulence EDR algorithm integrated into new WMO AMDAR Onboard Software Functional Requirements Specification (AOSFRS).

Medium-term Implementation Plan [5 years]

Task (Priority)	Sub-Task	Commence	Complete	Responsibility
2.2.1 Develop Turbulence Implementation Plan **(2)**		Q4 2013	Q1 2014	TT-AO
2.2.2 Negotiate with EU partner airlines for turbulence trials in Europe **(2)**		Q1 2014	Q3 2014	TT-AO

Activity Notes

2.2.2 Air France has discussed EDR with one of their Partner Airlines (Delta) and has indicated its interest in participating in a trial on EDR deployment.

2.3 Implement icing indication

Background

AMDAR downlink formats provide for the reporting of both icing accretion (to be reported if the aircraft has a sensor and provides the data to the avionics system) and de-icing activation. However none of the operational AMDAR programmes currently reports this information.

It is likely that the availability of humidity data from the aircraft platform may lead to the derivation of more direct benefits to airline and airline operations in terms of icing reporting and forecasting, which would strengthen the case for sensor integration and implementation.

Strategy

- Determine the requirements for reporting of icing-related parameters by AMDAR and, if required, develop planning for implementation of icing and de-icing reporting.
- The benefits of humidity information directly from sensor to cockpit will be clearly explained in the Benefits document (see Sub-Task 1.1.5).
- Collaborate with other agencies doing research into engine icing phenomenon (e.g NASA in the USA).
- Explain the benefits to aviation representatives in various meetings.
- Contact aircraft manufacturers about implementation

Other possible and potential applications, based on measurement of temperature and humidity, that should be explored and possibly itemized as benefits to aviation are: 1) possibility to detect conditions for contrail formation and avoidance 2) improved aircraft de-icing performance and operation; 3) improved fuel burn efficiency. 4) improved detection and avoidance of high ice water content engine icing.

Medium-term Implementation Plan [5 years]

Task (Priority)	Sub-Task	Commence	Complete	Responsibility
2.3.1 Implement icing and de-icing reporting within the global AMDAR programe **(1)**	2.3.1.a Develop a plan for implementation of icing and de-icing reporting	Q3 2014	2016	TT-AO
2.3.2 Inform aviation representatives about the benefit of humidity information directly to cockpit **(2)**		Q3 2014	Ongoing	SO/ARO, C/ET-ABO, C/TT-AO and AMDAR PMs
2.3.3. Discuss with aircraft manufacturer the implication of arranging humidity information from sensor to cockpit **(2)**		Q3 2014	Ongoing	SO/ARO, C/ET-ABO, C/TT-AO
2.3.4 Monitor and collaborate as necessary on investigations into engine icing issues, particularly with a view to impact on WVSS implementation		Q1 2013	Ongoing	TT-AO

3 Research and Development of New Aircraft-based Observations Technologies

3.1 Manage risks and opportunities associated with new and developing technologies in avionics, communications and metrology.

Background

The continuing increase in air traffic requires new systems with increased capacity for air traffic control and, therefore, also improved systems for communications. This is very evident in Europe with the evolution of the SESAR concept and in the USA with the Next-Gen concept. Avionics and communications belong to areas where development is rapid and many organizations and companies are involved. Changes in technology can potentially be expensive for AMDAR programmes if they would have to finance development and implementation of software for reporting of weather observations from aircraft.

The WMO Secretariat and TT-AO, follows this development e.g by participation in forums like ARINC Data Link Users Forum (DLUF). TT-AO and expert teams in AMDAR programmes follow the development also in observation technologies. Cockpit and cabin broadband communication will become available in the near future and it is essential that, if possible the AMDAR system takes advantage of the significantly greater bandwidth and lower communication charges.

Strategy

- Investigate and take advantage of new and developing technologies for communications and avionics (e.g. satellite TCP/IP communication solutions, data from ADS-Broadcast for GA aircraft and ADS-Contract for international oceanic traffic)

- Investigate and take advantage of new or developing technologies for aircraft-based observation of meteorological parameters.

Recent development

- Tasks exist in the work plan for study on new technologies to be undertaken by consultant (AMDAR Panel 15th Session).
- Expert on ADS-B/Mode S is member of TT-AO (S. de Haan, The Netherlands)
- Expert on TAMDAR is associate member of ET-ABO

Medium-term Implementation Plan [5 years]

Task (Priority 1-highest)	Sub-Task	Commence	Complete	Responsibility
3.1.1 A n WMO SSA for Study of new technologies to be put in place **(1)**		Q4 2013	Q2 2014	SO/ARO, C/TT-AO
3.1.2 Investigate potential sources of ABO data from other developing systems including AFIRS, ADS-B/Mode-S **(1)**		Q4 2013	Q4 2013	TT-AO
3.1.3 Undertake a study on current and developing technologies impacting on AMDAR **(1)**		Q4 2013	Q4 2014	TT-AO
3.1.4 Attend meetings of relevance to AMDAR Technical Development **(1)**		Q1 2013	Ongoing	TT-AO, SO/ARO

Activity Notes

4 Development and Maintenance of the Aircraft Observing System Quality Management System

4.1 Implement a Quality Management Framework for AMDAR that incorporates standardization and harmonization across national and regional programmes

Background

Observational data must have a defined and known quality. This is essential for the utilization of the data and the products generated from these data so that they will meet data user requirements.

An expert workshop dedicated to ABO Data Management was held in June 2012, addressing many issues related to data quality, focusing chiefly on data management and data quality monitoring. Data monitoring is currently largely based on a monthly cycle and, given the reliance on NWP for ABO data, it will be necessary for the ABOP to work towards the support of a (near) real-time monitoring programme.

The description of the data and its quality is based on provision and access to metadata. It should be noted here that aircraft based observation systems are different from most other observing systems in that the equipment (possibly with the exception of humidity sensors) does not belong to the NMHSs but to the participating airlines. Airlines have differing policies concerning the type of information they are willing to share with others. This may limit the access to some categories of metadata as well as the possibility to keep any metadata-database updated.

The ABOP through TT-AO is required to take the lead in investigating any data quality and systems issue that might arise.

Strategy

- Integrate existing regulatory material e.g. the AMDAR Reference Manual into WMO regulatory material (WIGOS/GOS and CIMO Guide).
- Refine and document within regulatory material the ABO Quality Management System and data management concepts developed at the Workshop on Aircraft Observing System Data Management of June 2012.
- Develop, define and implement the AMDAR metadata model through and in accordance with the relevant WIGOS processes and regulations.
- Investigate and resolve any data or systems issues, particularly making use of results from data monitoring programmes.
- Work towards improvement and update of requirements for ABO data quality management and data quality monitoring based on outcomes and recommendations of the Workshop on Aircraft Observing System Data Management.

Recent development

- Update to CIMO guide drafted
- Workshop on Aircraft Observing System Data Management held in June 2012 which also addressed many aspects of data quality control and data monitoring.
- Definition of an AMDAR metadata standard has been drafted and reviewed.
- Metadata Implementation Plan has been drafted.

Medium-term Implementation Plan [5 years]

Task (Priority)	Sub-Task	Commence	Complete	Responsibility
4.1.1 Implement a Quality Management Framework that incorporates standardization across national programmes **(1)**		Commenced	Ongoing	TT-AO
4.1.2 Continue work on regulatory material integration and maintenance under WIGOS regulatory framework. **(1)**		Commenced	Ongoing	ET-ABO, TT-AO
4.1.3 Investigate AMDAR Temperature Bias		Q1 2014	Q4 2014	TT-AO

Activity Notes

4.1.1. This Quality Management Framework should take into account:

1) Data management;

2) Metadata management;

3) Data quality monitoring for metrological systems; and,

4) Systems and data monitoring and evaluation.

4.1.2. This task refers to the migration of material from the AMDAR Reference Manual to the WIGOS and CIMO guides.

4.1.3. E-AMDAR is developing a pilot project to transfer E-AMDAR metadata to WMO required standards.

4.2 Develop a Global Aircraft Observations Data Management Framework

Background

The AMDAR data management framework is quite well developed and robust. A significant issue that was raised at the Workshop on Aircraft Observing System Data Management was the establishment of a global data centre for ABO data.

The AMDAR programme operators are required to complete the migration to the use of binary message formats for GTS data transmission by November 2014.

Strategy

- Review and refine the ABO Quality Management System and data management concepts developed at the Workshop on Aircraft Observing System Data Management of June 2012
- Develop, define and implement the AMDAR metadata model through WIGOS
- Establish the Global Aircraft-Based Observation Data Centre

Recent development

- Workshop on Aircraft Observing System Data Management held in June 2012 which addressed many aspects of data management and data quality monitoring.
- The new WMO General AMDAR BUFR Template was approved by CIMO 1st May 2012

Medium-term Implementation Plan [5 years]

Task (Priority)	Sub-Task	Commence	Complete	Responsibility
4.2.1 Establish AO Data Centre (**2**)		Q1 2013	Q4 2015	SO/ARO, C/ET-ABO
4.2.2 Document and refine regulations for ABO data management within the WIGOS manual and guide **(1)**	4.2.2.a Revise regulations on data management in the AMDAR Reference Manual and consolidate in the WIGOS regulatory material	Q1 2013	Ongoing	ET-ABO
	4.2.2.b Review and document regulations for management of ICAO data sources	Q1 2013	Q4 2014	ET-ABO
4.2.3 Develop and implement the AMDAR Metadata model in accordance with WIGOS **(1)**		Q3 2013	Q4 2014	

Activity Notes

4.3 Standardize AMDAR software function across avionics systems and optional sensors (e.g. water vapour) across aircraft

Background

There exist two standard onboard software specifications for automatic weather reporting, ARINC 620 and AAA and these are implemented in several different versions in various aircraft types. Although the two specifications to some extent are similar they do not offer the same options and the same degree of flexibility. Furthermore, updating is needed from time to time as the meteorological requirements will change e.g. with the introduction of new sensors or new parameters. Clearly there will be benefits to having a single standardized and flexible software package with the capability to be flexible and extensible for adaption to future needs.

Strategy

- Determine the strategy and practice in relation to use of the AOSFRS and the AEEC ARINC 620 standard containing the definition of the Met Report.
- Cooperate with consultants as needed for software development
- Cooperate with avionics vendors and DSPs for software development.
- Cooperate with airlines for onboard implementation of the improved software
- Standardisation related to WVSS will be developed under Activity 2.1.
- Standardisation related to turbulence will be developed under Activity 2.2.
- Determine the strategy and practice in relation to the use the of the AOSFRS and the AEEC ARINC 620 standard containing the definition of the Met. Report.

Recent development

- Meteorology Report updated to version 5 in the AEEC industry standard ARINC 620.
- New WMO AMDAR Onboard Software Functional Requirements Specification – AOSFRS completed through WMO Special Service Agreement with consultant.

Medium-term Implementation Plan [5 years]

Task (Priority)	Sub-Task	Commence	Complete	Responsibility
4.3.1 Undertake negotiations with avionics providers for supporting AMDAR software development. **(1)**	4.3.1.a Approach Teledyne Controls and Honeywell to implement AOSFRS as a standard catalogue avionics item	Q2 2014	Q4 2014	TT-AO
	4.3.1.b Approach other avionics providers to implement AOSFRS as a standard catalogue avionics application	Q3 2013	Ongoing	TT-AO

Activity Notes

4.3.1Cooperation with Avionics Vendors, or airlines having competence for software development, is essential to facilitate access to of-the-shelf AMDAR software. Negotiation is ongoing concerning software for Boeing B777.

4.4 Manage the data processing and quality assurance for other sources of aircraft data transmitted on the GTS including data provided through ICAO

Background

Some aircraft data e.g. those collected according to ICAO regulations are ingested on the GTS by WAFCs but also – illegitimately - by ATCs/ATMs without any quality control. It is very good that airlines collect these data and make them available, but it is not acceptable that the data quality is unknown. Cooperation will have to be established with ICAO and other organization supplying data to the GTS to resolve any data quality issue. The management and quality control of ICAO data is currently a significant issue that requires a resolution to satisfy all parties involved.

Strategy

- Work with ICAO to develop data and data quality management practices for ADS data sources in line with the DM Framework in Annex 3.

Recent development

- This problem was raised with ICAO at the AMDAR Panel meeting in November 2011 and subsequently by ET-ABO in September 2013.
- The ABOP supported a working paper by IATA putting forward a proposal that a QC system be developed for ADS data - WMO proposed a solution for this issue and the ABOP has commenced dialogue with ICAO relating to this development.

Medium-term Implementation Plan [5 years]

Task (Priority)	Sub-Task	Commence	Complete	Responsibility
4.4.1.a Establish cooperation with ICAO for implementation of quality management of ADS-C data. (**1**)		Q4 2013	Q4 2014	SO/ARO, C/ET-ABO,TT-AO

5 Aircraft Observing System Training and Outreach

5.1 Develop methods and material for promoting Aircraft-based Observations and the AMDAR Programme.

Background

It is critical to the maintenance and continued development of the AMDAR observing system that the interests of Members are represented and promoted to the important aviation organisations, associations and forums.

WMO promotes AMDAR by maintaining the ABO and AMDAR areas of the WMO website, publishing the AMDAR Newsletter and maintaining the News and Events website. Monthly statistical reports are maintained on the WMO web site and notification of update disseminated to national contact focal points. An important priority activity is to develop benefits documents and materials that can be used by Members to make the case of AMDAR participation to prospective airline partners.

Strategy

- Use the WMO/ABO website, the AMDAR News & Events site, the email forums and relevant social media to ensure that AMDAR and ABO are promoted to NMHSs and the aviation industry.
- Continue the development of business case and benefit documents and materials to ensure NMHSs have, or are given access to, the necessary information to develop their own business cases and airline partnerships.
- Ensure new programmes comply with standards and guidelines (WIGOS regulations and QMS).
- Development of benefits and business case documents and material is covered under Activity 1.1.

Recent activities

- WMO/ABO Website revised and updated.
- News & Events site with 6 volumes of the Newsletter published.
- AMDAR Projects & Collaboration site for Members established.
- Latest regional workshop for AMDAR held in November 2011 (Mexico)
- Requirements for an online COMET Training and Awareness module on AMDAR have been defined and the development has been costed. Co-funding arrangements with NOAA in progress.

- WMO SSA commenced to produce two papers on AMDAR data impact to be published in an AMS publication

Medium-term Implementation Plan [5 years]

Task (Priority)	Sub-Task	Commence	Complete	Responsibility
5.1.1 Continue to develop online information and resources **(1)**	5.1.1.a Investigate development of online Education and Training Module **(2)**	Commenced	Q2 2014	ET-ABO
	5.1.1.b Continue to develop and enhance WMO AMDAR website	Commenced	Ongoing	SO/ARO, ET-ABO
5.1.2 Publish Newsletter biannually **(1)**		Commenced	Ongoing	SO/ARO
5.1.3 Collaborate with aviation organisations and related bodies for promotion and education of AMDAR and ABO **(3)**	5.1.3.a Establish MoU with participating airlines for cross-promotion on websites	Q3 2014	Ongoing	ET-ABO
	5.1.3.b Liaise with ICAO and IATA re website promotion of AMDAR	Q3 2013	Q2 2014	SO/ARO, Ch-ET-ABO

Activity Notes

5.1.1.a The Training Module has been costed. Funding arrangements to be finalized.

5.2 Conduct training and outreach activities in support of Core Activities.

Background

The AMDAR Panel has in the past conducted regional workshops on AMDAR development and it is expected that this activity will continue in the future in similar format and under similar guidelines. As with AMDAR Panel meetings, such events could be held in conjunction with meetings of ET-ABO and TT-AO. Continuing the work of the AMDAR Panel, the ABOP will provide support for Workshops on AMDAR though input of technical guidance and training.

WMO presents an update on AMDAR to the aviation industry e.g. at DLUF once or twice every year. Opportunities to do the same in other forums should be taken by the ABOP, the Secretariat or through representation by national or regional AMDAR programmes as convenient and cost effective, e.g in their meetings with cooperating airlines.

Strategy

- Building on the transfer of AMDAR to WMO, the ABOP should endeavour to make use of the resources and expertise of the WMO Education and Training Department (ETD) for delivery of workshops and training.
- Plan, coordinate and work with WMO ETD to hold workshops and training seminars on AMDAR and ABO in areas and with stakeholders strategic to AMDAR programme development.
- Ensure that the ABOP is represented at biannual meetings of the AEEC DataLink Users Forum (DLUF).

Recent Activity

- Regional workshop on AMDAR was last held in Mexico City in November 2011.
- AEEC DLUF meetings have been attended by various AMDAR Panel and ET-ABO members over the past several years.

Medium-term Implementation Plan [5 years]

Task (Priority)	Sub-Task	Commence	Complete	Responsibility
5.2.1 Conduct training and outreach activities in support of Core Activities (**1**)	5.2.1.a Conduct workshops in Middle East and in RA I	Ongoing	Mid-East workshop Q1 2014 RA I Q2 2014	SO/ARO, ADO, C/ET-ABO
	5.2.1.b Representative of ABOP to attend upcoming RA Sessions	Q1 2014	Ongoing, based on schedules of RA Sessions	SO/ARO, C/ET-ABO C/TT-AO
	5.2.1.c. Conduct workshops in regions and areas targeted for coverage enhancement.	Ongoing	Ongoing	SO/ARO, ADO, C/ET-ABO
5.2.2 Attend biannual meetings of AEEC DLUF (**1**)			Ongoing	SO/ARO, ET-ABO, TT-AO

6 Management and administration of the Aircraft-based Observations Programme

6.1 Conduct meetings of members and stakeholders

Background

For background on the structure of ABOP, see: http://www.wmo.int/pages/prog/www/GOS/ABO/ABOWorkTeams.html

It is considered important that the biennial meetings of ET-ABO and TT-AO are open not only to official team members but also to other Members actively working with AMDAR programmes and those considering starting AMDAR programmes. This will promote AMDAR and facilitate coordinated planning.

It is essential that the WMO Secretariat coordinates the planning process and arranges follow-up meetings. These cannot all be physical meetings and, therefore, meetings by WebEx (or similar systems) and telephone will be important.

Strategy

- Teams to meet in alternate years.
- Meeting of ET-ABO to be possibly held in location targeted for development and in conjunction with workshops.
- Work plans and budgets for ABOP teams to be revised and updated on an annual basis by the end of December.
- Seek to ensure WMO regular budget to support meetings in future.

Recent activities

- Work Team online area established on WMO/ABO Website
- ET-ABO Session 1 was held in Geneva on 10-13 September 2013
- TT-AO Session 1 has been planned for Q1 2014

Medium-term Implementation Plan [5 years]

Task (Priority 1-highest)	Sub-Task	Commence	Complete	Responsibility
6.1.1Hold TT-AO in Q1 2014 **(1)**			1 April 2014	SO/ARO, Ch/TT-AO
6.1.2 ET-ABO Session 2 to be held in 2015 **(1)**		Q1 2015	Q4 2015	SO/ARO, Ch/ET-ABO
6.1.3 Develop plans for the ET and TT meetings within the current 5 year period including regular (e.g. at least quarterly) online teleconferences		Q1 2013	Ongoing	SO/ARO. Ch/ET-ABO, Ch/TT-AO

6.2 Coordinate planning activities

Background

The two teams of the ABOP are obliged to develop and seek approval of their respective work plans and budgets for use of the AMDAR Trust Fund under its ToR.

Strategy

The WMO Secretariat and ET-ABO will:

- Take initiative for the planning process so that plans on global and regional levels are harmonized
- Keep frequent contact with those involved in the planning
- Give feedback on all draft plans

Recent activities

- 2013-2014 Work Plan ET-ABO approved.
- 2013-2014 Work Plan TT-AO approved.
- Budget for 2013-16 developed and approved.

Medium-term Implementation Plan [5 years]

Task (Priority 1-highest)	Sub-Task	Commence	Complete	Responsibility
6.2.1 Develop annual work plan for ET-ABO and TT-AO (1)		Q1 2013	Ongoing	SO/ARO, C/ET-ABO C/TT-AO
6.2.2 Develop annual budget for expenditure of the Trust Fund based on team work plans **(1)**		Q1 2013	Ongoing	SO/ARO, C/ET-ABO C/TT-AO

6.3 Monitor and evaluate the Aircraft -Based Observations Programme

Background

The WMO Secretariat and the respective leadership of the Technical Commission (TC) teams are responsible for monitoring the performance of the work teams and their progress on achieving the aims and objectives of the ABOP.

Strategy

- Each team will have responsibility for reporting to its parent body within the relevant WMO Technical Commission.
- Expenditure from the AMDAR Trust will be monitored and administered by the WMO Secretariat and authorized by the Technical Commissions as defined in the ToR for the Trust Fund.
- The annual update of the work plans and the budget should incorporate documentation of progress and actual expenditure versus planned.

Recent activities

- Work plans and budgets were developed and approved for each team for 2013-14 and proposed for 2014-2015.

Medium-term Implementation Plan [5 years]

Task (Priority 1-highest)	Sub-Task	Commence	Complete	Responsibility
6.3.1 Regular reporting from ET-ABO **(1)**	ET-ABO report to ICT-IOS and CBS		Q1 2014	C/ET-ABO
6.3.2 Regular reporting from TT-AO **(1)**	TT-AO will report to CIMO MG		Q1 2014	C/TT-AO

7 List of Acronyms

AAA ACARS ACMS AMDAR Software package for Teledyne avionics
ABO Aircraft-based Observations
ABOP Aircraft-Based Observations Programme
ACARS Aircraft Communications and Reporting System
ADO AMDAR Development Officer (consultant to WMO Secretariat)
ADS-B Automatic Dependent Surveillance Broadcast
ADS-C Automatic Dependent Surveillance Contract
AFIRS Automated Flight Information Reporting System (FLIGHT company)
AMDAR Aircraft Meteorological Data Relay
AOSFRS WMO AMDAR Onboard Software Functional Requirements Specification
A-RIP AMDAR Regional Implementation Plan
ARINC Aeronautical Radio, Incorporated (data link service provider)
ARINC 620 Aviation communications industry standard, contains i.a. weather data reporting
A-SIP AMDAR Strategy and Implementation Plan
ATC Air Traffic Control
ATM Air Traffic Management
CBS Commission for Basic Systems (of WMO)
COMET Educational programme of of UCAR
DENCHAR Development and Evaluation of Novel Compact Hygrometer for Airborne Research (European research project within EUFAR – European Facility for Airborne Research)
DEVG Derived Equivalent Vertical Gust (metric of air turbulence)
DLUF ARINC Data Link Users Forum
ECMWF European Centre for Medium-range Weather Forecasting
EDR Eddy Dissipation Rate (metric of air turbulence)
EGOS-IP CBS Implementation Plan for the Evolution of the Global Observing System
E-AMDAR European AMDAR Programme under EUMETNET
EUMETNET European Meteorological Network (economical interest group with 29 European NMHSs as members)
ET-ABO Expert-Team on Aircraft-Based Observations (of CBS)
ETD WMO Education and Training Department
EUROCONTROL European Organisation for the Safety of Air Navigation
FAA Federal Aviation Authority (USA)
FAAM Facility for Airborne Atmospheric Measurements (Collaboration between UK Met Office and National Environment Research Council)
FLYHT Avionics company
GA General Aviation
GLFE Great Lakes Field Experiment
GOS Global Observing System
GTS Global Telecommunication System
IATA International Air Transport Association
ICAO International Civil Aviation Organization (of the United Nations)
IOM Instrument and Observation Methods (WMO report series)

Mode S see ADS-B
NASA National and Aeronautics and Space Administration (USA)
NCAR National Center for Atmospheric Research (USA)
NOAA National Oceanic and Atmospheric Administration (USA)
NWP Numerical Weather Prediction
NWS National Weather Service (i.a. In USA)
QMS Quality Management System
RA Regional Association (RA I – RA VI of WMO) and also Regional airline
RRR Rolling Review of Requirements
R-WIP Regional WIGOS Implementation Plan
SESAR Single European Sky ATM Research (project under EUROCONTROL)
SITA Société Internationale de Télécommunications Aéronautiques (avionics company, data link service provider)
SO-ARO WMO Scientific Officer Aircraft and Remotely-sensed Observations
SSA Special Service Agreement
Teledyne Control Avionics company
TAMDAR Tropospheric AMDAR, observation system from Panasonic Avionics
TCP/IP Transmission Control Protocol/Internet Protocol (Architecture for data network communication)
ToR Terms of Reference
TT-AO Commission for Instruments and Methods of Observation (of WMO)
UCAR University Corporation for atmospheric Research (USA)
US-AMDAR The AMDAR programme in the USA (also known as MDCRS)
WAFS World Area Forecast System
WebEx Internet-based video conference system
WIGOS WMO Integrated Global Observing System
WIS WMO Information System
WVSS-II Water Vapour Sensing System (from SpectraSensor Inc.)
WWW World Weather Watch

Annex 1: Aircraft-Based Observations Programme Core and Long-term Activities

Core Activity 1: Enhancement of AMDAR Observing System Coverage

Long-term Activity	Description	Activities	Outputs	Outcomes/Impacts	Justification	Priority (1-3)	Timeframe
1.1	Extend global AMDAR coverage, particularly over upper air data sparse and developing areas.	1. Regional and national workshops; 2. Training and Outreach; 3. Liaison with NMHSs, Airlines and Avionics service providers; 4. Liaison with stakeholders and data users; 5. Studies on data coverage and airline capabilities; 6.Assessment and use of impact studies; 7. Facilitate, coordinate and promote data provision among and outside AMDAR programmes.	1. AMDAR Workshops; 2. AMDAR training materials; 3. Extension of AMDAR expertise; 4. Results and reports of studies; 5. AMDAR data provided beyond national AMDAR Programme requirements.	1. More airlines recruited; 2. More national AMDAR programmes; 3. Better AMDAR global data coverage; 4. Significant, positive impact on applications and for Data Users.	EGOS-IP Action G19	1	Ongoing to 2025
1.2	Address the requirement for national, regional and global optimization	1. Promote the implementation and use of AMDAR Data Optimisation Systems; 2. Specification of AMDAR data requirements; 3. Specification of optimization requirements; 4. Liaison with WMO/CBS/E-EGOS.	1. Studies and reports 2. Specifications 3. Optimised AMDAR Programmes	1. More efficient use of Member resources 2. Improved AMDAR data coverage	EGOS-IP Action G20	1	Ongoing to 2025

Long-term Activity	Description	Activities	Outputs	Outcomes/Impacts	Justification	Priority (1-3)	Timeframe
1.3	Extend AMDAR Programme to GA aircraft and coverage of regional airports.	1. Research, trial and study of new and developing aircraft observing systems, avionics systems, communications systems and sensors appropriate for GA aircraft application 2. Develop standards associated with new aircraft observing systems for GA aircraft 3. Assist Members in the implementation of proven and approved aircraft observing systems for GA aircraft.	1. Studies and reports 2. Manuals and guides 3. Programmes incorporating GA aircraft	1. More airlines recruited 2. Better AMDAR global data coverage 3. Significant, positive impact on applications and for Data Users.	EGOS-IP Action G24	3	Ongoing to 2025

Core Activity 2: Extension of the AMDAR System

Long-term Activity	Description	Activities	Outputs	Outcomes/Impacts	Justification	Priority (1-3)	Timeframe
2.1	Implement water vapour measurement	1. Undertake planning and project coordination in the implementation by Members of WV measurement within the AMDAR Observing System 2. Coordinate negotiations and interactions with sensor manufacturers 3. Coordinate negotiations and develop agreements for standardization with aircraft and avionics manufacturers and aviation standards authorities. 4. Promote the	1. Studies and reports 2. Business cases for NMHSs and Airlines 3. International WV Project 4. Certificates (STCs) for aircraft 5. Agreements between the relevant stakeholders.	1. WV capability for AMDAR Programme 2. Significant, positive impact on applications and for Data Users. 3. Ex-works availability AMDAR + humidity + particles.	EGOS-IP Action G22	1	Ongoing to 2025

		standardization of aircraft equipment by merging the interests of meteorology pilots, airlines, ATM, NMHSs, Environmental control for - better deicing warning, - deicing efficiency, - NWP, - contrail warning.					
2.2	Implement turbulence measurement.	1. Undertake planning and project coordination in the implementation by Members of turbulence measurement within the AMDAR Observing System; 2. Coordinate negotiations and interactions with algorithm developers; 3. Coordinate negotiations for standardisation with aircraft and avionics manufacturers and aviation standards authorities.	1. Specification of turbulence requirements for reporting in software standards. 2. AMDAR Software applications that include reporting of turbulence (EDR). 3. A standard turbulence metric reported from the AMDAR Programme.	1. Turbulence data produced and used by the aviation, NWP and forecasting communities. 2. Improved monitoring and prediction of turbulence in support of the aviation industry. 3. More acceptance of the AMDAR programme as a contributor and benefit to aviation operations.	EGOS-IP Action G23	1	Ongoing to 2015
2.3	Implement icing indication in cockpit.	1. Undertake planning and project coordination in the implementation by Members of icing measurement within the AMDAR Observing System; 2. Coordinate negotiations for standardisation with aircraft and avionics manufacturers and aviation standards authorities.	1. Specification of requirements for transferring humidity and temperature data to an icing indication. 2. Decision by at least one aircraft manufacturer to implement icing indication in cockpit	1. Concrete discussions with aircraft manufacturers will be possible. 2.a. Improved icing indication available in cockpit. 2.b. Installation of WVSS ex-works on airlines' expense possible	EGOS-IP Action G23	2	Ongoing to 2020

Core Activity 3: Research and Development of New Aircraft Observations Technologies

Long-term Activity	Description	Activities	Outputs	Outcomes/Impacts	Justification	Priority (1-3)	Timeframe
3.1	Manage risks and opportunities associated with new and developing technologies in avionics, communications and metrology.	1. Research, trial and study of new and developing aircraft observing systems, avionics systems, communications systems and sensors appropriate for aircraft application; 2. Attend and report on appropriate aviation meetings and forums that develop and define standards relating to avionics and communications 3. Develop standards associated with new aircraft observing system technologies; 4. Assist Members in the implementation of proven and approved technologies for aircraft observing systems.	1. Reports, expert advise and recommendations to Members. 2.a. Insight into the development driven by other stakeholders in aviation, and 2.b. Gives some possibility to influence development by describing the needs from meteorology. 3. Prepararation of new aircraft for AMDAR service. 4. Upgraded or modernized observation system	1. Increased knowledge, readiness to improve observation systems or routines. 2. Preparedness for future changes or investments 3. and 4. Maintaining or expanding AMDAR fleets	EGOS-IP Action G21	1	Ongoing to 2025

Core Activity 4: Development and Maintenance of the Aircraft Observing System Quality Management System

Long-term Activity	Description	Activities	Outputs	Outcomes/Impacts	Justification	Priority (1-3)	Timeframe
4.1	Implement a Quality Management Framework for	1. Coordinate (expert) meetings, projects and tasks related to the development of standards;	1. and 2. New standards as guidance to Members 3. Assistance to	1. and 2. Improved understanding for the need of data management 3. Improved data	WMO-ER-4	1	Ongoing to 2025

	AMDAR that incorporates standardization across national programmes, taking into account: 1. Data management; 2. Metadata management; 3. Quality control for metrological systems; 4. Systems and data monitoring and evaluation.	2.Approve and document standards; 3. Coordinate the implementation of standards by Members.	Members	management, improved data quality			
4.2	Develop a National and Global Aircraft Observations Data Management Framework.	1. Coordinate (expert)meetings, projects and tasks related to the development of a DMF; 2. Approve and document the DMF; 3. Coordinate the implementation of the DMF by Members.	1. and 2. New standards as guidance to Members 3. Assistance to Members	1. and 2. Improved understanding for the need of data management 3. Improved data management, improved data quality	WMO-ER-4	1	Ongoing to 2015
4.3	Standardize AMDAR software function across avionics systems and optional sensors (e.g. water vapour) across aircraft.	1. Coordinate with and attend meetings with representatives of airlines, avionics manufacturers, and other aviation bodies as appropriate; 2. Coordinate implementation of the establishment of software and sensor standards.	1. Reports, expert advise and recommendations to Members. 2. AMDAR fleets with upgraded or expanded capabilities.	1. Increased knowledge, readiness to improve observation systems or routines. 2. More observations, more parameters or observations of improved quality.	EGOS-IP Action G21	2	Ongoing to 2020
4.4	Manage the data processing and quality assurance	1. Coordinate with and attend meetings with representatives of data	1. and 2. Reports and expert advice to Members and data	1. and 2. Access to more aircraft observations and with known, improved,	WMO-ER-4	2	Ongoing to 2025

	for other sources of aircraft data transmitted on the GTS including data provided through ICAO.	providers (e.g. ICAO); 2. Coordinate the establishment of standards for aircraft data other than AMDAR (ADS, Mode-S).	providers	quality.			

Core Activity 5: Aircraft Observing System Training and Outreach

Long-term Activity	Description	Activities	Outputs	Outcomes/Impacts	Justification	Priority (1-3)	Timeframe
5.1	Develop methods and material for promoting and developing Aircraft Observations and the AMDAR Programme.	1. Define, develop and manage the content of the Aircraft Observing System WMO website; 2. Specify and coordinate the development of promotional material, e.g. flyers, papers, posters, etc; 3. Specify and coordinate the development of training material for Members.	1. Continuous improvement of the website. 2. More and improved promotional material. 3. New or improved training material.	1. Increased interaction by Members and inproved service to Members. 2. ABO becomes beter known and attracts more participants. 3. Wider active use of ABO data by Members in addition to the NWP.	EGOS-IP Action G20	2	Ongoing to 2025
5.2	Conduct training and outreach activities in support of Core Activities.	1. Conduct technical workshops for Members; 2. Coordinate and conduct meetings, workshops and conferences with appropriate stakeholders.	1. Reports, expert advice and increased knowledge to Members 2. Reports, expert advice and increased knowledge to participants.	1. a. ABO becomes beter known and attracts more participants. 1.b.. Wider active use of ABO data by Members in addition to the NWP. 2. ABO becomes beter known and attracts more participants.	EGOS-IP Action G20	2	Ongoing to 2025

Core Activity 6: Management and Administration of the Aircraft Observing System Programme

Long-term Activity	Description	Activities	Outputs	Outcomes/Impacts	Justification	Priority (1-3)	Timeframe
6.1	Conduct meetings of members and stakeholders.	1. Coordinate meetings of ET-ABO; 2. Coordinate meetings of ET-AIR; =TT-AO?? 3. Coordinate meetings of the Aircraft –based Observations Programme Management Group (APMG).	1. – 3. Reports and recommendations	1. – 3. Better governance and efficiency	WMO-ER-4	1	Ongoing to 2025
6.2	Coordinate planning activities.	1. Develop plans for extension and enhancement of the AMDAR Observing System.	1. Plans and recommendations.	1. Possible extension and enhancement of the existing system	WMO-ER-4	1	Ongoing to 2025
6.3	Monitor and evaluate the Aircraft Observations Programme.	1. Develop and maintain diagnostics and tools for monitoring and evaluating progress of the development of the Aircraft Observations Programme.	1. Tools for monitoring and evaluation.	1. Improved quality of ABOP and better use of resources.	WMO-ER-4	2	Ongoing to 2025

Annex 2: EGOS-IP Aircraft-based Observations Development Actions

The fundamental basis for global development of the aircraft-based observing sytem and the AMDAR system is the IMPLEMENTATION PLAN FOR THE EVOLUTION OF GLOBAL OBSERVING SYSTEMS (EGOS-IP) and, in particular, the actions on Aircraft meteorological stations under Recommendations for the evolution of Surface-Based Sub-system of GOS, Section 5.3.1.3:

5.3.1.3. Aircraft meteorological stations

In the northern hemisphere, meteorological data derived from aircraft stations, especially the automatic data produced by the AMDAR system, are an excellent complement to the data derived from the radiosonde network. This system produces vertical profile data in the vicinity of airports and single-level data when aircraft are flying at cruise levels. It has been shown through NWP impact studies that their impact on numerical forecasts has a magnitude similar to the impact of the radiosonde network. In the southern hemisphere and in the tropics the aircraft data coverage is very poor although there is some potential for developing it, preferably in a way that is complementary to existing AMDAR and radiosonde networks.

Extending aircraft observations data coverage is important and can be achieved through the extension of the programme to new airlines and aircraft operating in data-sparse areas. The programme coverage can also be improved greatly through an optimization process. This can be achieved through two general activities. Firstly, existing programmes can be extended so that internationally-operating aircraft are activated for reporting outside the national areas or regions that tend to be restricted by national programme constraints. Secondly, one can enhance the capabilities of programmes to control data output through the wider development and implementation of automated data optimization systems. Such systems, whilst allowing the efficient growth of the programme outside and across international boundaries with appropriate agreements in place, will also offer the potential to utilize the AMDAR system as an adaptive observing network (capability to change the reporting regime to serve the changing purposes of programme areas).

Action G19

Action: Improve AMDAR coverage over areas that currently have poor coverage, especially within Regions I and III, focussing on the provision of data at airports in the tropics and southern hemisphere where vertical profiles are most needed to complement current radiosonde data coverage and its likely evolution.

Who: NMSs, NMHSs in collaboration with commercial and other airlines, RAs. AMDAR Programme Management to lead the action.
Time-frame: Continuous.
Performance indicators: Number of airports where AMDAR measurements are taken. Amount of vertical profiles and AMDAR data in general, measured by the usual indicators of current AMDAR programmes.

Action G20
Action: Extend the AMDAR programme so as to equip and activate more internationally operating fleets and aircraft (i.e. fleets and aircraft flying to and between international airports outside the country of origin) and extend the use of data optimization systems in support of improved upper-air observations coverage and efficiency, and also the adaptive functionality of the system.
Who: NMSs, NMHSs in collaboration with commercial and other airlines, RAs, CBS and AMDAR Programme Management. AMDAR Programme Management to lead the action.
Time-frame: Continuous.
Performance indicators: The number of airports where AMDAR measurements are taken and number of vertical profiles per day at each airport. The number of international airlines and aircraft equipped to provide AMDAR observations. The adaptability of the AMDAR programme.

Action G21
Action: Given the nature of the aircraft observing system as an increasingly critical and
basic component of the Global Observing System, seek to establish agreements with airlines and the aviation industry to ensure that the system, infrastructure, data and communications protocols are supported and standardized within relevant aviation industry frameworks so as to ensure continuity and reliability of the system.
Who: NMSs, NMHSs in collaboration with national and other airlines and aviation industry, RAs, CBS and AMDAR Programme Management. AMDAR Programme Management to lead the action.
Time-frame: Continuous.
Performance indicators: Agreements made with aviation industry partners and organizations. Data produced by humidity sensors are now used operationally from an increasing number of aircraft both in the USA and Europe, and it is critical and strategic to continue this development in order to converge to systems which measure humidity as well as air pressure (pressure altitude), temperature and wind as do radiosondes. Such an extension will provide an increased opportunity to restructure the upper-air observing systems for efficiency and improvement in coverage.

Action G22

Action: Continue the development and operational implementation of humidity sensors as an integrated component of the AMDAR system to ensure that humidity data is, processed and transmitted in the same way as wind and temperature.

Who: NMSs, NMHSs in collaboration with commercial and other airlines and TCs (CBS, CIMO) and AMDAR Programme Management. AMDAR Programme Management to lead the action.

Time-frame: Continuous.

Performance indicator: A number of aircraft providing humidity data in real-time.The lower cost of aircraft observations in comparison to the radiosonde information as well as the reduced reliance on ground-based systems and infrastructure make it an ideal candidate system for rapid and reliable expansion of upper-air observations for developing countries in support of local, regional and global data users. Such an expansion should be undertaken in parallel with the necessary development action to facilitate the provision and utilization of data. Observations of turbulence and icing are also made on some aircraft and it is desirable to expand this capability of the AMDAR system with these parameters in support of aviation operations and safety as well as other meteorological applications.

Action G23

Action: Enhance and extend the capability to report observations of atmospheric turbulence and icing variables as an integrated component of the AMDAR system and in line with the requirements of the relevant programme areas and data users.

Who: NMSs, NMHSs in collaboration with airlines and TC (CBS, CIMO) and AMDAR Programme Management I, RAs. AMDAR Programme Management to lead the action.

Time-frame: Continuous.

Performance indicator: A number of aircraft providing atmospheric turbulence and icing data in real-time.

Another source of important potential progress is the research and development actions associated with AMDAR systems for small aircraft, usually referred to as General Aviation (GA) aircraft. These aircraft tend to fly and generate level data in the middle troposphere whilst operating over shorter regional flight legs. This type of observation would be very useful for regional and local purposes and could also contribute to global data coverage. Priority should be placed on equipping aircraft operating on, to and out of isolated islands and remote sites where radiosonde observations are not available, e.g. deserts, islands and the Arctic. The impact of existing data sets (derived from deployment of the commercial communications and sensor system) on high resolution NWP models has been evaluated and compared

to other observing systems such as profilers and radars. The results are encouraging: see for example Moninger et al. (2010) and Benjamin et al. (2010). In spite of several technical snags, AMDAR systems for GA aircraft do have potential for contributing to the improvement of data coverage of vertical profiles of AMDAR measurements (wind, temperature, humidity, turbulence and icing) in the lower troposphere and this development should be pursued whilst taking into account the potential associated with new and developing technologies such as ADS-B and Mode S.

Action G24

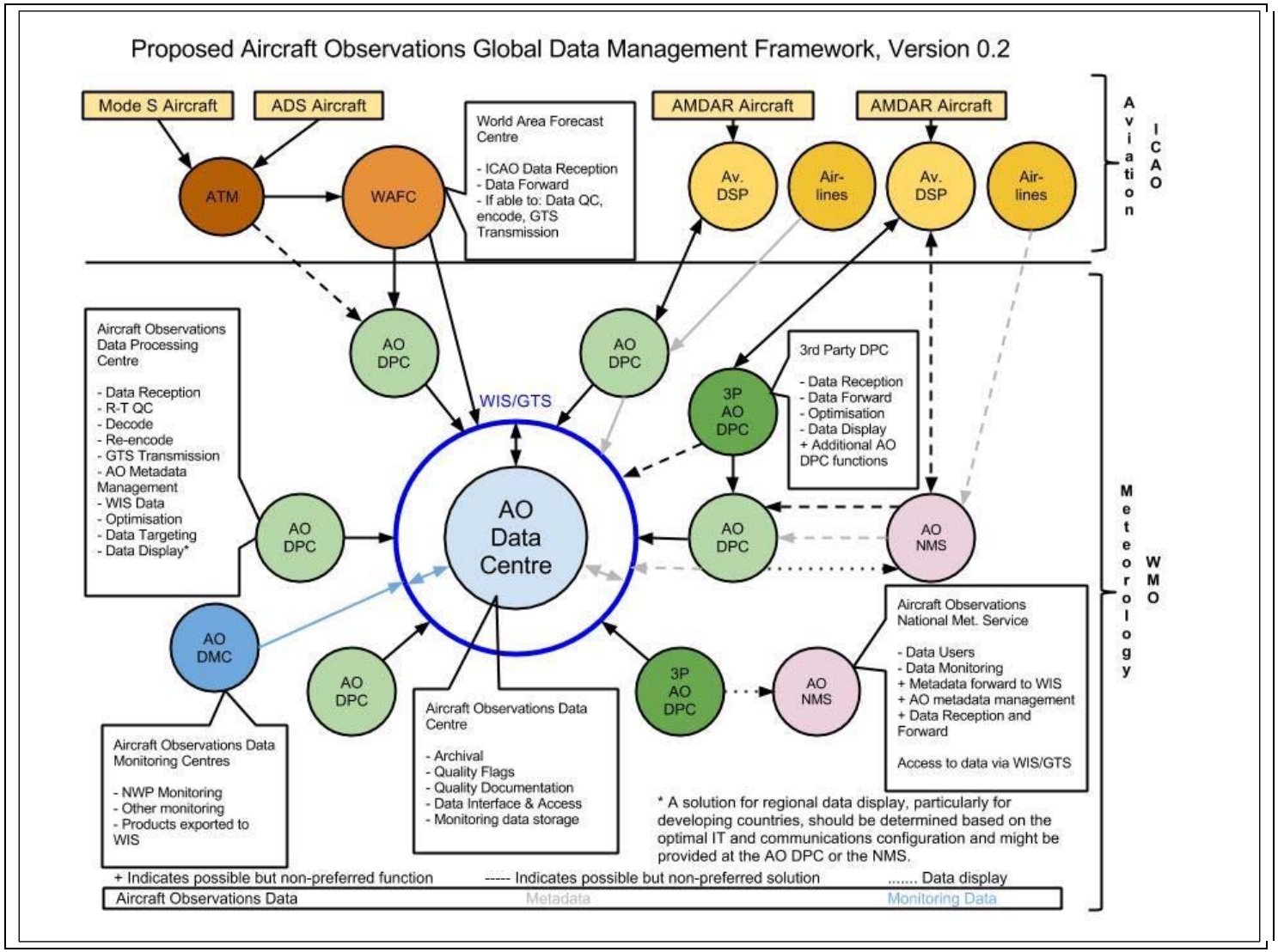
Action: Develop and implement operational AMDAR systems which are adapted to small aircrafts operating at the regional scale and flying at low altitude in the troposphere.

Who: Airlines operating small aircraft, NMSs, NMHSs in collaboration with RAs, CBS and

AMDAR Programme Management. AMDAR Programme Management to lead the action.

Time-frame: Continuous.

Performance indicator: Number of small aircrafts providing AMDAR observations operationally in real-time.

Atmospheric composition measurements for several species, aerosols and volcanic ash are measured on some aircraft, but more in research than in operational mode. The actions related to atmospheric chemistry are documented in section 5.3.8.4.

Annex 3: Proposed Aircraft Observations Global Data Management Framework