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CONSULTATIVE MEETINGS ON HIGH-LEVEL POLICY ON SATELLITE MATTERS

SECOND SESSION

GENEVA, SWITZERLAND

18-19 FEBRUARY 2002

FINAL REPORT


GEOS

1. ORGANIZATION OF THE SESSION

1.1 Opening of the session *(Agenda item 1.1)*

The second session of the Consultative Meetings on High-Level Policy on Satellite Matters was held at the World Meteorological Organization (WMO) Headquarters in Geneva, Switzerland from 18 to 19 February 2002 under the chairmanship of the President of WMO, Dr J.W. Zillman. The session was opened at 09:30 hours on Monday, 18 February by the Secretary-General of WMO, Prof. G.O.P. Obasi. He noted over the last two years, since the endorsement by the WMO Executive Council in June 2000 of guiding principles for the Consultative Meetings, that the progress achieved had been remarkable. One noteworthy example was the expansion of the World Weather Watch's space-based component of the Global Observing System to include a new constellation of appropriate Research and Development satellite missions. The Secretary-General also thanked three participants who were authors of a draft new technical document describing the long-term future development of the space-based component of the Global Observing System. He indicated that it was appropriate and timely, in the context of the growing demands for accurate and timely observations on weather, water and climate to review and upgrade the system taking into account current advances in satellite observation and technology. He expressed his belief that the dialogue established through the Consultative Meetings would continue and strengthen to the benefit of all. In closing, he thanked participants and organizations for the contributions in support of the objectives of the World Meteorological Organization.

The Chairman thanked the Secretary-General for his encouraging remarks and especially for his reinforcement of the priority that needs to be given to the education and training of personnel from developing countries in the application of satellite information. He reiterated the appreciation of the WMO Executive Council to the satellite operators for having first articulated the jointly felt need for a mechanism for dialogue on high level policy on satellite matters. Although this is only the second of the Consultative Meetings, a great deal has been achieved so far as would clearly become evident during the session.

The Chairman also identified what he saw as one of the most important challenges facing the participants in the Consultative Meetings. That is, how to help ensure that WMO plays its part in facilitating the progressive development of an integrated global observing system for the earth that brings together the space-based and *in situ* contributions from both the research and operational communities in an optimal partnership of intergovernmental and non-governmental organizations and agencies. While WMO's primary focus is on atmospheric observations, it is important that these be effectively integrated with observations of the ocean and land surface through a partnership approach with the Intergovernmental Oceanographic Commission (IOC) of UNESCO and the various other observing system sponsors to ensure an efficient robust overall framework for environmental observation, application and service provision.

Some of the particular issues on which advice will be very helpful to WMO relate to the scope for better internal coordination of WMO's own observing systems as well as ways of working more effectively with other UN agencies and non-governmental bodies in developing a more broadly based approach to the future role of satellites in environmental observations. It will be important for WMO itself to ensure that the advice received through the Consultative Meetings feeds effectively into WMO work on the future role and operation of National Meteorological and Hydrological Services (NMHSs) and into the development of WMO's formal Long-term Plans. The ultimate objective should be an efficient integrated international architecture for space and *in situ* based observation and service provision. The prospect of its achievement has been greatly enhanced by the initiative of the Consultative Meetings and the Chairman looked forward to the dialogue during the second meeting contributing to real progress on several fronts. The agenda for the session has been structured to ensure this is achieved.

1.2 Adoption of the Agenda *(Agenda item 1.2)*

The agenda for the session was adopted and is reproduced in Annex I.

1.3 Working arrangements for the session (*Agenda item 1.3*)

The working arrangements for the session were agreed upon. It was also agreed that the work of the session would be conducted mainly in Plenary. The working languages of the session were English, French, Russian and Spanish, and the documentation and report were in English only.

The list of participants is attached as Annex II.

2. ACTIONS DERIVING FROM EC-LIII *(Agenda item 2)*

2.1 The second session noted that there were four action items resulting from decisions made at the fifty-third session of the WMO Executive Council and that each would be discussed under a separate agenda item.

2.2 The second session was informed that the fifty-third session of the WMO Executive Council had reviewed the support provided by the present Research and Development (R&D) satellite missions to WMO Programmes. The review highlighted the significant contributions already made by R&D satellite missions in support of WMO Programmes. The Executive Council was convinced of the value in articulating the positive impacts experienced by WMO Members in utilizing data from R&D satellite missions. Thus, the Executive Council requested the preparation of a report for the next Executive Council to be reviewed by the second session of the Consultative Meetings. The report would be a synthesis of input from the operational user communities on the utility of existing R&D data including persuasive arguments related to their impacts from R&D satellite missions. The second session noted that it would review the draft report under agenda item 4.

2.3 The second session noted that the fifty-third session of the WMO Executive Council had endorsed the *Guidelines for requirements for observational data from operational and R&D satellite missions* developed at the first session of the Consultative Meetings on High Level Policy on Satellite Matters. The *Guidelines* had been forwarded to the space agencies and two space agencies (ESA and NASA) had responded positively.

2.4 NASA confirmed to the second session its commitment to WMO and to the world community to make observations available for research and applications without restriction to whomever requests it. It further indicated that this policy would apply to all current and future missions. Therefore, since data from NASA's Earth observation missions were readily available, its satellites can be considered *de facto* as part of the space-based component of the Global Observing System.

2.5 ESA confirmed that it was establishing a dialogue towards the development of information for WMO Members concerning the availability of specific data and products from ESA's EO satellite missions, and in particular from the ENVISAT mission scheduled for launch in early March 2002. ESA further informed that second session that it would propose to its Programme Board for Earth Observation (PB-EO), to jointly organize a dedicated, specific Announcement of Opportunity (AO) to foster the use of ESA Earth Observation data by the WMO community.

2.6 NASDA indicated that its future satellite missions including ADEOS II and the GCOM series were candidate systems to contribute to the new R&D constellation for the space-based component of the GOS.

2.7 The Russian Aviation and Space Agency (Rosaviakosmos)) indicated that experimental and R&D instruments on board its operational METEOR 3M N1 satellite as well as on its future Ocean series and other missions could be considered as a potential contribution to the space-based component of the GOS.

2.8 The second session was then informed that the fifty-third session of the WMO Executive Council had requested CBS to review the space-based component of the GOS with the goal of defining an overall system that included appropriately identified R&D satellite missions. The second session noted that it would discuss the CBS activities under agenda item 3.

2.9 Finally, the second session noted that the fifty-third session of the Executive Council had discussed a proposal on the need to consider enhanced coordination within a future space-based Global Observing System. The Executive Council had noted that there were many related and complex issues and that it would be appropriate for further reviews to be conducted by relevant coordinating groups. In particular, the Executive Council suggested that the second session of the Consultative Meetings on High-Level Policy on Satellite Matters review the issues with the expectation that the fifty-fourth Executive Council could be informed of the review and appropriate recommendations. The second session noted that it would discuss enhanced coordination within the future space-based Global Observing System under agenda item 5.

3. REVIEW CBS PROGRESS IN CHANGES TO THE SPACE-BASED COMPONENT OF THE GLOBAL OBSERVING SYSTEM *(Agenda item 3)*

3.1 The second session recalled that at the fifty-third session of the WMO Executive Council, the Commission for Basic Systems (CBS) was requested to review the space-based component of the Global Observing System with a goal of defining an overall system that included appropriately identified R&D satellite missions.

3.2 The session reviewed actions and progress made by CBS concerning its review of the space-based component of the Global Observing System. It noted that CBS had in place a process to continually review the requirements placed upon the World Weather Watch, by WMO and WMO-related Programmes, for observations from the Global Observing System (GOS). It was the CBS plan that the GOS would evolve as an integrated system. The integrated system would include the capabilities of *in situ*, and remote sensing (both space- and surface-based), observing systems such that an integrated system that best met the needs of WMO Members could be implemented and maintained.

3.3 The second session was informed that the CBS process to achieve such an integrated observing system had three essential components:

(a) A rolling review of the requirements for observational data to meet the needs of WMO Programmes;

(b) A continuous assessment of the capabilities of new and emerging observing systems; and,

(c) Updating of the Regulations and Guidance to Members on the implementation of new and emerging systems that were to form a part of the GOS. The Regulations are found in the Manual on the GOS while the guidance is found in the Guide to the GOS and in other WMO (non-regulatory) documentation.

3.4 The second session was then informed of the activities within CBS including the work of two CBS Expert Teams (ETs) within the Open Programme Area Group on Integrated Observing Systems and a Task Team on Regulatory Material (TT). These Teams were addressing issues relating to:

(a) The contribution that new and emerging space-based observing systems are making to the GOS;

(b) Improving current and future satellite system utilization; and,

(c) Ongoing work to update the Manual on the GOS and the Guide to the GOS so as to enable Members to benefit from developments in space-based observing systems.

3.5 The second session was convinced that the CBS activities would lead to appropriate updates to the Manual on the GOS to reflect the expansion of the space-based component of the GOS to include appropriate Research and Development satellite missions. It encouraged CBS to continue to persevere in this important task.

3.6 CBS identified three immediate issues of primary importance to its work: (1) the coordination of equator crossing times, (2) direct broadcast and alternative dissemination methods, and (3) comparable data content from polar-orbiting satellites in AM and PM orbits. The second session noted that the coordination of equator crossing times would be further discussed in its session agenda and that direct broadcast and comparable data content would be discussed within the Expert Team structure of CBS in April 2002. The second session felt that the issue of alternative dissemination methods was of utmost importance to WMO and that some Members had experience with examples of such systems that were very cost effective. It encouraged CBS to remain aware of the capabilities of future telecommunications systems for the distribution of satellite data and products from operational and R&D data streams.

4. REVIEW REPORT ON THE UTILITY OF EXISTING R&D SATELLITE DATA FROM THE OPERATIONAL USER COMMUNITY *(Agenda Item 4)*

4.1 The second session reviewed a report that was a synthesis of input from the operational user communities on the utility of existing R&D data including persuasive arguments related to their impacts from R&D satellite missions. It recalled that the fifty-third session of the WMO Executive Council was of the opinion that R&D satellite data and products were greatly contributing to WMO Programmes and had requested that such a report be prepared.

Synopsis of the utility of R&D satellite data and products for WMO Members

4.2 The second session noted that the responses on the utility of R&D satellite data and products covered the full spectrum of WMO Regions as well as a good cross-section of developed and developing countries. Countries from both the Northern and Southern Hemispheres, tropical, mid- and high-latitude as well as those with coastlines and those landlocked had responded. Most disciplines and application areas including NWP, hydrology, climate, oceanography, agrometeorology, environmental monitoring and detection and monitoring of natural disasters were included. Thus the second session was confident that most potential user communities had an input.

4.3 The second session recalled that the use of operational satellite data and products by WMO Members had, in the past, been well-documented in the Application of Satellite Technology Progress Report series (WMO TD/No. 995, WMO TD/No. 863, WMO TD/No. 716, WMO TD/No. 628, WMO TD/No. 569, WMO TD/No. 431, etc.). It also noted that the series would continue on a biennial basis. Such reports were available through the WMO Satellite Activities web site and Office.

4.4 An indicator of the utility of R&D satellite data and products was the list of specific satellite missions mentioned in the country reports as follows: ADEOS-II, Aqua, ERS-1, ERS-2, ENVISAT, DMSP, GCOM, GIFTS, Jason-1, Okean, QuikScat, Resource-O, Terra, Topex/Poseidon, TRMM, SPOT and more. While the second session recognized that DMSP was not an R&D satellite, it was also not considered part of the present space-based Global Observing System but was mentioned continually in the country reports. The data from all of the above satellites were being used operationally.

4.5 A second indicator was the breadth of WMO Programmes and associated application areas supported by data and products from the R&D satellites. While not complete, the list included specific applications within the disciplines of agrometeorology, weather forecasting, hydrology, climate and oceanography including: monitoring of ecology, sea-ice, snow cover, urban heat island, crop yield, vegetation, flood, volcanic ash and other natural disasters; tropical cyclone forecasting; fire areas; oceanic chlorophyll content; NWP; sea height; and CO_2 exchange between the atmosphere and ocean.

4.6 Another indicator was the impact that R&D satellite data and products when used for operational purposes. Here, WMO Member comments provided both an overview as well as specific insights. The second session noted that the positive remarks from WMO Members covered almost the full gamut of applications as well the various R&D missions.

4.7 Comments with an overall viewpoint included the following statements. While most NMHS operations depend critically on data and products from operational satellite missions, R&D systems have now become an integral part of some NMHSs' operations. One Member noted that the initiative of WMO to include data of R&D systems as early and as extensively as possible into operational use was strongly supported. Satellite data were an indispensable element for development of the Sahel countries. Altimeter data with orbital corrections have a large impact on high-resolution, eddy-resolving ocean models and have provided a major quasi-operational contribution. The extension of a major NWP centre's forecasting system to an integrated Earth system (encompassing atmosphere, ocean, ocean surface waves and land) able to monitor the environment and natural hazards would only be possible with a synergistic exploitation of future satellite systems provided by the R&D and operational space agencies.

4.8 Comments related to specific R&D missions included the following statements. The Total Ozone Mapping Spectrometer (TOMS) provided critical image data that confirmed the existence of the Antarctic ozone hole and TOMS equivalent capability will be continued with the flight Ozone Mapping Instrument (OMI) on NASA's Chemistry mission in 2003 and subsequently the Ozone Mapping and Profiler Suite (OMPS) on NPOESS, being developed for flight on afternoon (1330 ascending) NPOESS platforms as well as GOME-2 on the Metop series, the follow-on to the GOME on ERS-2. Positive impact results from the use of SPOT's HRV data for sea-ice and flood monitoring. All-weather observations from Okean's RLS BO were of great importance to make sea-ice observations for sea routes. QuikScat data enabled WMO Members with oceanic forecasting responsibilities to rapidly detect incorrect ship observations and was often the only source of verification over coastal areas apart from land based METARS which usually do not show the true wind speed at sea. ERS scatterometer data provided unprecedented spatially detailed and accurate wind vector fields near the ocean surface. TRMM data allowed better identification of the centre positions and the wind radii of tropical cyclones. An Observing System Experiment (OSE) with QuikScat (SeaWinds) data showed remarkable positive impact over the Southern Hemisphere and its derived wind vectors were equivalent to that observed by ships and buoys. In another NWP OSE using total precipitable water from TRMM's TMI, remarkable positive impact was achieved on forecasted wind fields for 850 hPa and height fields for 250 hPa over the tropics. Additionally, SST analysis could be obtained even over cloud-covered areas with TRMM's TMI and some ocean data assimilation systems totally depended on the sea surface height observed by TOPEX/POSEIDON. Experience gained in the last few years has demonstrated that data from R&D satellites can be used operationally; a striking example is the use of ERS/SAR (Synthetic Aperture Radar) for the monitoring of sea ice. Information difficult to detect with

operational meteorological satellites, such as monitoring in the large water basin is detected using Aqua's MODIS.

4.9 The second session was convinced that the short synopsis demonstrated that many R&D satellite missions were already being used operationally by WMO Members in support of many applications and the impacts had been impressive. The expansion of the space-based Global Observing Systems to formally include a Research and Development constellation to complement the existing operational meteorological satellites should provide global observations to assist WMO Members in meeting their ever increasing challenges.

4.10 The second session felt strongly that the report including the synopsis would be very beneficial to WMO Members and thus it was important that there be wide distribution amongst WMO Members. Furthermore, it felt that similar reports should be prepared on a regular basis. The second session suggested that the WMO Secretariat develop a standard format for the preparation of future reports similar to that done for the Application of Satellite Technology Progress Report series. The reports on the utilization of R&D data and products by the operational user communities should be prepared on a biennial basis to be phased with the Application of Satellite Technology Progress Report series. This would provide for a report on the operational use of R&D satellite data and products every second year with reports from the Application of Satellite Technology Progress Report series in the intervening years. The second session also suggested that the present report be prepared as a WMO Satellite Activities Technical Document after soliciting input from WMO Members for additional inputs or reformulation of the present report into the new, to-be-developed standard format.

4.11 The second session then reviewed evaluations by GCOS, WCRP, JCOMM and CHy of the planned satellite missions in support of observational requirements for their programmes. All programmes noted the ongoing activities to develop and/or refine statements of guidance that would provide their user communities with expectations on their needs as well as providing input to space agencies as to the priority areas where emphasis must be placed.

GCOS

4.12 The second session noted that GCOS provided an initial overview of the satellite observational requirements, bearing in mind that specific evaluations were being prepared through the CBS Rolling Review of Requirements Process. For meteorological observations, GCOS had developed a two-stream strategy that takes into account the range of requirements for climate data. There were *comprehensive* global networks and *baseline* global networks, and each stream had specific requirements.

4.13 *Comprehensive global networks* provide data that are assimilated in global models to generate real-time predictions and delayed-mode reanalyses of global climate. Required scope and density of these networks continued to expand as the capabilities of models increase. For example, the use of measurements of atmospheric constituents in reanalysis and prediction was expected to increase over the next few years as ozone, aerosols and carbon dioxide data were shown to explain significant variance in the atmosphere. Satellite data would have a major contribution to the comprehensive networks, as they could provide genuinely global coverage.

4.14 *Baseline global networks* provided high-quality homogeneous data that were used to monitor global climate and to calibrate data from the comprehensive networks. These data were relatively sparse compared with the comprehensive networks. However, they were required to be sufficiently dense to ensure that large-scale climate indicators could be generated consistently from them for all key climate variables. Although the initial focus had been on *in situ* baseline data, it was important that baseline satellite data systems also be included in this stream. For example, baseline systems should be maintained for MSU radiances and the solar constant.

4.15 Each baseline network involved an end-to-end system to ensure data were collected, processed and archived effectively. Monitoring Centres were identified to provide real-time monitoring of the availability and basic quality of the collected data. Analysis Centres ensured the homogeneity and quality of the data and generate basic products. The data were archived at World Data Centres.

4.16 The baseline networks were also vital to reanalysis, as they provided the only means of ensuring temporal homogeneity in the comprehensive data. Thus the *in situ* baseline data, such as the GCOS Surface Network (GSN) and the GCOS Upper Air Network (GUAN), provided calibration for more spatially-dense datasets, including satellite data. Although the GSN and GUAN observing sites have been identified, a substantial number of stations were not meeting the basic standards required of baseline data. As most of the sites were selected on the basis of their historical records, the current deficiencies are generally associated with the world-wide decline in support for infrastructure. Thus, targeted funding was essential to resolve most of the current deficiencies.

4.17 The space agencies participating in the second session noted that targeted funding to support GCOS networks, and the GUAN in particular, was essential and agreed to investigate further the possibility to meet such resource requirements.

4.18 The second session noted that GCOS had established observing principles for climate monitoring which related to satellite systems as well as *in situ* observations (see Annex IV). It felt it important that WMO formally recognize and endorse such principles and suggested that the Executive Council and Congress might consider such recognition. A formal WMO endorsement would greatly assist space agencies in obtaining the necessary resources to meet the principles for future satellite systems.

WCRP

4.19 The second session was informed that WCRP undertook extensive research into the Earth's climate system at the global scale, and regionally or locally into key climate processes. WCRP made major use not only of operational space systems, but also primarily experimental or research systems which may not yet offer full operational continuity as a comprehensive global capability. A good example was the Tropical Rainfall Measuring Mission (TRMM) which provided a partial three-dimensional mapping of atmospheric liquid water, leading to innovative research in the dynamics and parameterization of precipitating convection. As well as these particular, possibly time-limited data sets, WCRP did need and depend on the long-term continuity and stability of remotely-sensed data, careful calibration of sensors, overlapping data, full documentation of data processing methods, and the like.

4.20 Furthermore, as well as being a major customer for remotely-sensed data, WCRP was very much a partner of space agencies in the planning and development of new missions, as well as the calibration and validation of new sensors with the use of baseline research networks (for example the Baseline Surface Radiation Network, BSRN) and the organization of field experiments focussed on specific physical processes (for example the Continental Scale Experiments for hydrology).

4.21 WCRP noted that satellite data were fundamental to the research projects it co-ordinated in the analysis of the global climate system, including global monitoring, process studies, parameterization developments, data assimilation and model validation, and there was close liaison between these research projects and the space agencies. With regard to observational data requirements, WCRP noted that they fell generically into four different areas:

- atmospheric, land-surface and hydrological data, including: global distribution of water vapour, clouds, and radiation necessary for the validation of precise atmospheric radiation schemes; a global mapping of precipitable liquid water, as planned to be

provided by the Global Precipitation Measurement (GPM) mission; global soil moisture as a key parameter in clarifying the role of the land-surface in the climate system; and global three-dimensional distribution of tropospheric winds (e.g. from satellite-borne lidar);

- oceanographic data, comprising altimetry and scatterometer measurements and possibly surface salinity;

- cryospheric data, including sea-ice limits and concentrations, sea-ice motion vectors, ice-sheet and ice-stream topography, and iceberg distribution;

- stratospheric data, including three-dimensional ozone distribution, aerosols, trace constituents and gravity waves.

4.22 In summary, the second session noted that:

- Broad GCOS needs for meteorological observations would be summarized through the CBS Rolling Review of Requirements process, including evaluations for seasonal to interannual prediction, climate monitoring, and climate change detection.

- End-to-end GCOS baseline observing systems needed to be identified and maintained for satellite measurements, such as MSU radiances and the solar constant.

- The *in situ* GSN and GUAN baseline systems were vital for the calibration and evaluation of satellite and other data, but many sites were not fully functional due to the world-wide decline in infrastructure. Targeted funding was essential to lead to significant improvements in the overall performance of GSN and GUAN.

- The basic principles developed for GCOS observing systems needed to be applied to all satellite systems that aim to serve the climate community.

- WCRP and GCOS requirements ranged across all components of the Earth's climate system, including atmospheric, land-surface, hydrological, oceanographic, cryospheric, and stratospheric data.

- WCRP depended not only on operational systems but also on primarily experimental systems and on the development of new sensors. Both WCRP and GCOS contributed directly to the validation of space systems.

- Experimental missions realized and under development by the major space agencies had been guided by and responded in great part to WCRP requirements and should enable substantial progress in research activities related to climate during the present decade. There was a strong need for continued coordination between space agencies and the climate research community in the design of future missions.

4.23 The second session encouraged WCRP to identify and articulate issues concerning gaps in existing or planned satellite systems, and possible weakness in data management activities for research purposes at future sessions of the Consultative Meetings.

JCOMM

4.24 The second session was informed that the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) clearly recognized that ocean satellites would be a crucial component of the future composite, integrated, operational ocean observing system,

the *in situ* component of which will be coordinated through JCOMM itself. In this context, the development and operation of ocean satellite systems, as well as interaction with the satellite operators, were of major importance to the Joint Commission. The second session noted that a substantive discussion on ocean remote sensing took place at JCOMM-I (Akureyri, June 2001). The session also established a position of satellite rapporteur, within the Observations Programme Area Coordination Group.

4.25 JCOMM had identified a number of pathways for interaction with satellite operators, at the same time specifying that care should be taken to ensure that the message in each case was the same. These pathways include: the present consultative meetings; the Commission for Basic Systems' (CBS) Rolling Review of Requirements Process; the Coordination Group for Meteorological Satellites (CGMS), and through the Integrated Global Observing Strategy Partnership (IGOS-P), in concert with the Global Ocean Observing System (GOOS) However, both the JCOMM satellite rapporteur and the JCOMMOPS coordinator had participated in the recent session of the CBS OPAG IOS Expert Team on Observational Data Requirements and the Redesign of the Global Observing System at which they prepared a first draft of a Statement of Guidance relating to marine and ocean services. It is intended to finalize the draft during the course of the coming few months, in consultation with the JCOMM Services and Observations Coordination Groups. This Statement of Guidance would serve additional purposes of identifying and specifying possible deficiencies in the World Meteorological Organization/Committee of Earth Observation Satellites (WMO/CEOS) database as it related to ocean data requirements for marine services, as well as possible inadequacies and incompatibilities mentioned in the IGOS-P Oceans Theme document.

4.26 The second session encouraged JCOMM to ensure, in stating its observational data requirements, that consistency with other oceanographic related programmes' observational requirements should be sought especially with those of the IGOS-P Oceans Theme. Furthermore, the second session encouraged JCOMM to confirm its observational data requirements as quickly as feasible. The second session suggested that JCOMM also consider the needs of ocean data assimilation such as exemplified in the GODAE Project and that as it participated in its Rolling Review of Requirements it should consider the role and importance of future relevant satellite missions.

CHy

4.27 The second session was informed of the observational data requirements for the Commission for Hydrology (CHy). Some key variables were identified including precipitation, soil moisture, surface temperature, radiation forcing, water vapour, snow and ice, water level and gravimetry. The second session noted the importance of these variables that could greatly assist in flood forecasting and other natural disasters. However, the second session noted that the detailed list of observational requirements were somewhat inconsistent with the presentation. CHy informed the session of its new initiative to more clearly identify and articulate its observational data requirements as well as its intention to participate in the Rolling Review of Requirements process. The second session also indicated that there were many new opportunities for improved observations of hydrological phenomena. For example, the new SEVIRI imager onboard MSG should provide better characterization of cloud coverage and distribution and possibly precipitation. Additionally, there were initiatives within EUMETSAT and the European Union that would provide new capabilities for hydrologists. The Coordinated Enhanced Observing Period (CEOP) also would provide a unique opportunity to combine satellite observation with *in situ* observation, contributing to global water cycle and hydrology studies and applications.

4.28 The second session then discussed an issue that could have unintended consequences for the observational community in general. There sometimes existed the impression that overly enthusiastic statements of expected performances from new observing systems, and in this case from the space agencies, would serve to justify the reduction of existing ones. The hydrological community felt that it was particularly susceptible to such occurrences. The session noted that

there could be many reasons attributable to observing network reductions and that overly enthusiastic statements of expected performances was but one. CHy further noted that the benefits of hydrological data were not always readily recognized and this often led to network reduction.

5. REVIEW PROPOSAL FOR ENHANCED COORDINATION FOR THE SPACE-BASED COMPONENT OF THE GLOBAL OBSERVING SYSTEM *(Agenda item 5)*

5.1 The second session reviewed a proposal by Dr A.I. Bedritsky related to enhanced coordination within a future space-based component of the Global Observing System. It recalled that Dr Bedritsky had presented to the fifty-third session of the WMO Executive Council a document on enhanced coordination to create a global meteorological/environmental satellite system. The document contained possible mechanisms for the creation of future international space-based observation systems. The fifty-third session of the Executive Council had noted that there were many related and complex issues and that it would be appropriate for further reviews to be conducted by relevant coordinating groups. In particular, the Executive Council suggested that the second session of the Consultative Meetings on High-level Policy on Satellite Matters review the issues with the expectation that the fifty-fourth session of the Executive Council could be informed of the review and appropriate recommendations.

5.2 The second session discussed a range of measures to strengthen coordination. It agreed that it was a generally accepted fact that in recent years the role and use of the operational meteorological satellites - as well as the Research and Development environmental satellites (R&D satellites) - have grown significantly in WMO Programmes. The constant growth in the number and capabilities of national and international satellite systems, both operational and R&D, including their complexity, corresponding high cost and interactions with other WMO global systems (i.e., Global Data Processing and the Global Telecommunications Systems) suggested that WMO should review the structure through which it interacted with those entities providing satellite systems.

5.3 It recalled that for many years under the aegis of the Coordination Group for Meteorological Satellites (CGMS), there have been mechanisms to coordinate relevant operational matters of importance to WMO National Meteorological and Hydrological Services (NMHSs) with those space agencies which operate meteorological satellites. Those space agencies have accepted a commitment to meet WMO requirements for a space-based component of the World Weather Watch's Global Observing System (GOS). However, since the present space-based component of the GOS does not include R&D satellites, no such coordinating group exists for data, products and services from these satellites. While the Committee for Earth Observation Satellites (CEOS) and the IGOS Partnership did provide fora for interaction amongst satellite operators and with international user communities, it did not provide a mechanism comparable to that of CGMS with WMO. The inclusion of R&D satellite systems into the space-based component of GOS would more than double the need for external coordination mechanisms. Firstly, there will be unique coordination needs between WMO and R&D space agencies. Secondly, there will be coordination needs between operational and R&D space agencies in such areas as frequency coordination, orbit coordination including equator crossing-times, standardization of data formats, standardization of user stations.

5.4 In addition to the external coordination needs, there should be a comparable internal WMO structure. At present, there was a small activity office whose primary focus had been coordination between WMO and the operational meteorological satellite operators, and coordination between the various WMO and supported programmes. A secondary focus for the activity office had been coordination with CEOS.

5.5 The second session noted that the necessary coordination with the R&D space agencies had emerged slowly during the second half of the last decade and was now placing greater

demands on many WMO and supported programmes, e.g., GCOS, WCRP, HWR, GAW, JCOMM, etc. The response within each WMO and supported programme had been to establish indigenous satellite expertise. The result of the many new focused satellite groups had been to disperse the satellite expertise.

5.6 To better satisfy the needs of all WMO and supported programmes for satellite data, products and services from both operational and R&D satellites and in consideration of the increasing role of both types of satellites, the second session felt it appropriate to propose an expansion of the present mechanisms for coordination within the WMO structure and cooperation between WMO and the operators of operational meteorological satellites and R&D satellites.

5.7 The second session felt that there were four inter-related issues to be addressed in the need to improve coordination. First, was the external coordination mechanisms themselves (for example CGMS, CEOS and the IGOS Partnership), second the WMO interfaces with those external mechanisms, third the WMO internal programme structure as described by the long-term planning process and fourth the internal WMO Secretariat structure. The second session agreed to focus its discussion in the first three areas.

External Coordination

5.8 The second session felt that a means to improve cooperation with both operational meteorological and R&D satellite operators would be through an expanded CGMS.

5.9 CGMS could act as a principal forum for the necessary dialogue between WMO and the satellite operators as well as for discussions between satellite operators, especially for technical matters concerning data formats, work station configuration, commonality of satellite instruments and missions, coherent and coordinated mission planning, data dissemination systems, etc.

5.10 It noted that the expansion of the space-based components of the GOS, GAW, GCOS and WHYCOS would be step-wise, i.e., only those R&D satellite system operators that have the potential to contribute to WMO and supported programmes would be considered, and would have the option of following the guidelines.

5.11 Once criteria were met, then it would be appropriate for WMO to suggest to CGMS Members the inclusion of the new R&D satellite operator. The second session noted that WMO had already suggested to CGMS an expansion of its membership to include IOC as a full CGMS member. This WMO proposal was fully supported by CGMS satellite operators. Inclusion of any satellite operator into the space-based GOS would require the agreement of all CGMS Members.

5.12 WMO's role within CGMS would be to state the observational and system requirements for WMO and supported programmes as they relate to the expanded space-based components of the GOS, GAW, GCOS and WHYCOS. CGMS satellite operators would make their voluntary commitments to meet the stated observational and system requirements. WMO would, through its Members, strive to provide CGMS satellite operators with operational and pre-operational evaluations of the benefit and impacts of their satellite systems. WMO would also act as a catalyst to foster direct user interactions with the CGMS satellite operators through available means such as conferences, symposia and workshops.

Internal coordination

5.13 The second session felt that it was important that the internal structure within WMO be expanded and strengthened. The expanded structure should be constituted so as to allow WMO to have a single focus point for satellite matters for all WMO and supported programmes. The supported programmes would include the: World Weather Watch Programme, World Climate Programme, World Climate Research Programme, Global Climate Observing System, Hydrology

and Water Resources Programme, Atmospheric Research and Environment Programme, Education and Training Programme and the Technical Cooperation Programme.

5.14 Since the Commission for Basic Systems had primary responsibility for the present space-based component of the GOS, it should also retain this responsibility as the GOS expands. Thus, its Open Programme Area Groups (and associated expert teams) should respond to the requirements of the other supported programmes in formulating the system design for the expanded GOS. The system design would be formalized within the Manual and Guide for the GOS and presented to the expanded CGMS.

Summary

5.15 Implementation of both the external and internal cooperation and coordination mechanisms were of equal importance if WMO were to provide the international perspective in constituting an efficient and effective space-based system comprised of operational meteorological and R&D satellites that would provide the satellite data, product and services to meet the needs of all WMO supported programmes.

5.16 The second session agreed that there was a pressing need to strengthen coordination especially in light of the recent expansion to include R&D satellite missions as part of the space-based component of the GOS. While it would be a decision of CGMS whether it expanded its remit as suggested in the proposal by Dr Bedritsky, it appeared that such an expansion would be timely and opportune and will be likely to be supported by CGMS members. The second session thus concentrated on the WMO interface with external coordination mechanisms. In doing so, it was convinced that it would be very advantageous for the satellite agencies to have effective linkages into the WMO structure and a central focal point in the WMO Secretariat for satellite activities.

5.17 Thus, the second session suggested that WMO conduct its own review of its internal coordination of satellite activities to ensure that it was optimum for the present and perceived future needs as well as providing an appropriate framework for efficient interaction with external mechanisms. This review should take into consideration the emphasis that WMO placed on the contribution satellite systems were making to WMO and supported programmes and the large expenditures by those space agencies contributing to the space-based component of the WMO GOS. In the light of its discussion, the second session encouraged the Secretariat in consultation with the President of CBS and others, as appropriate, to explore the full range of options, including that of a WMO Space Programme as contained in Annex III. The structure and content as contained in Annex III should serve as the starting point for the Secretariat review which should be submitted for consideration by EC-LIV. The second session felt that it would be appropriate to provide more detail than shown in the Annex to make it clear as to the structure, scope and linkages implied in any new WMO Space Programme. The second session also agreed that the present structure was insufficient to respond to the new demands resulting from the expansion of the space-based component of the GOS to include the R&D constellation. In order for WMO to take advantage of the new technologies to better serve its Members, it was of primary importance to enhance the coordination as suggested in the proposal by Dr Bedritsky. The second session agreed that such a review could also lead to enhancement of the WMO interface with external mechanisms. The conclusions of the review should be reported to the forthcoming Executive Council in June 2002.

6. REVIEW DRAFT WMO TECHNICAL DOCUMENT "THE ROLE OF SATELLITES IN WMO PROGRAMMES IN THE 2010S" *(Agenda item 6)*

6.1 The second session reviewed a preliminary draft of the WMO Technical Document on "The Role of Satellites in WMO Programmes in the 2010s" which was intended to update the last comparable technical document entitled "The Role of Satellites in WMO Programmes in the 1980s" by D.S. Johnson and I.P. Vetlov published in 1977. The second session noted that the update was being prepared by three primary authors: Dr G. Asrar, Dr T. Mohr and Mr G. Withee. It was envisioned that the final manuscript would be completed by July 2002 and ready for distribution prior to the next session of the Consultative Meetings.

6.2 The second session was felt strongly that the new Technical Document would be of great importance to WMO Members, not only to the NMHSs but also the larger communities found within Members. Such users would include policy decision makers or those involved with the IPCC assessment process for example. It thanked the three authors for their progress to date in noting that there would be widespread use of the new Technical Document by many user communities. It also suggested that the authors review the draft with a goal to make it more succinct possibly by including an early overview of the WMO programmes to which satellite systems contribute and by combining some of the materials found in the various chapters. However, it also noted there was an immediate need to have such a Technical Document and that it should be published as soon as possible. The second session also suggested that the present Chapter 8 could be edited and shortened somewhat for use in the final version. However, the present version could be published as a stand alone WMO Satellite Activities Technical Document possibly to include the report on the use of R&D satellite data and products by the operational user communities described in agenda item 4 above. Finally, the second session suggested that the new Technical Document also address in general terms the possible scope of an expanded and future integrated global observing systems.

7. ANY OTHER BUSINESS *(Agenda item 7)*

7.1 The second session discussed the issue of equator crossing time planning as presented by CGMS. The CGMS presentation included the current status of planning for operational polar-orbiting satellites, and their data formats and frequency and highlighted the recommendations that had been made at a CGMS Task Force on Coordination of Data Formats and Frequency Planning for Polar-Orbiting Satellite Meeting held in January 2001.

7.2 The second session noted that CGMS sought reactions to two relevant issues:

- Development of a global plan for equator crossing times in the morning and afternoon orbits; and
- Development of common ground receiving stations.

7.3 The second session noted the complexity of the issue and that more indepth analyses would need to be performed. However, it was unanimous in its belief that an optimized equator crossing time plan based on the totality of user requirements was essential. Such an optimization would also allow the development of contingency plans for the polar orbit. With regard to equator crossing times, the session suggested that the Executive Council and WMO Congress be informed of the need to formally articulate system requirements for an optimized equator crossing time plan. It also felt it very important that the direct broadcast service from all satellite operators should strive to have standardization in terms of frequency, data format and content where possible and thus allow commonality amongst ground receiving stations.

7.4 Additionally, the second session recognized that due to the large volumes of data expected from the satellite systems, alternative dissemination methods (ADM) that would complement and supplement the existing direct broadcast service would be a necessity for the

future space-based component of the GOS. It appreciated the ongoing initiatives within CGMS and CBS to address the issue and encourage them to give the issue highest priority.

7.5 The second session also recalled the need to identify data streams of importance to WMO Members especially for developing countries. Developing countries experienced many barriers that often precluded exploitation of the valuable data and products from satellite systems. The second session encouraged the relevant technical commissions, including CBS, CIMO, CHy and CAS, to keep such issues in mind when developing their future work programmes.

8. CLOSURE OF THE SESSION *(Agenda item 8)*

8.1 In reviewing its progress, the second session felt strongly that the dialogue between WMO and the satellite agencies as manifested through the Consultative Meetings was already proving very beneficial and agreed such sessions should be continued. Thus, it recommended that the third session of the Consultative Meetings on High Level Policy on Satellite Matters take place in January 2003 during the week of the WMO Bureau.

8.2 The Chairman thanked the participants, especially the representatives of the satellite agencies and user groups, as well as the members of the WMO Bureau and Executive Council, and the technical commission presidents and others for their very constructive contribution to the work of the session. The Chairman closed the session at 15h30 on Tuesday, 19 February 2002.

ANNEX I

PROVISIONAL AGENDA

1. ORGANIZATION OF THE SESSION

    1.1 Opening of the session
    1.2 Adoption of the agenda

2. ACTIONS DERIVING FROM EC-LIII

3. REVIEW CBS PROGRESS IN CHANGES TO THE SPACE-BASED COMPONENT OF THE GLOBAL OBSERVING SYSTEM

4. REVIEW REPORT ON THE UTILITY OF EXISTING R&D SATELLITE DATA FROM THE OPERATIONAL USER COMMUNITIES

5. REVIEW PROPOSAL FOR ENHANCED COORDINATION FOR THE SPACE-BASED COMPONENT OF THE GLOBAL OBSERVING SYSTEM

6. REVIEW DRAFT WMO TECHNICAL DOCUMENT “THE ROLE OF SATELLITES IN WMO PROGRAMMES IN THE 2010s”

7. ANY OTHER BUSINESS

8. CLOSURE OF THE SESSION

ANNEX II

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ANNEX III

WMO SPACE PROGRAMME (preliminary draft)

1. Objectives - Provide a strategic vision for WMO

Purpose and scope

To facilitate the development, operation and enhancement of the space-based components of the Global Observing System (GOS), Global Atmospheric Watch (GAW), Global Climate Observing System (GCOS) and the World Hydrological Cycle Observing System (WHYCOS).

Implementation of the enhanced space-based components of the GOS, GAW, GCOS and WHYCOS is through application of the concept that each Member country and appropriate international organization undertakes, according to its means, to meet certain responsibilities in the agreed globally cooperative scheme. The Programme's main functions are planning, organization and coordination of the facilities and arrangements at the global and regional levels, the design of observing networks, the standardization of observing and measuring techniques, the development and use of common communications and data management procedures, and the presentation of observations and processed information in a manner that is understood by all, regardless of language, and supporting activities that assist national Meteorological and Hydrological Services to fully participate in and obtain maximum benefits from the Programme.

2. Opportunities

In addition to the continuation of the meteorological satellite systems, the following R&D missions have the potential to make major contributions to the space-based components of the GOS, GAW, GCOS and WHYCOS:

Global Precipitation Mission (GPM),
Global Climate Observation Mission (GCOM),
EOS series,
ENVISAT,
Jason series.

3. Interactions

The WMO Space Programme (WSP) interacts with the internal constituent body structures contained in the appropriate technical commissions, i.e., (CBS, CAS, CHy, CCl, CIMO, CAgM, CAeM and JCOMM and the WMO Executive Council's Consultative Meetings on High-Level Policy on Satellite Matters (CM). It also interacts with WMO supported programmes, i.e., WCRP and GOOS. Externally, the WMO Space Programme interacts with the Coordination Group for Meteorological Satellites (CGMS), the Committee on Earth Observation Satellites (CEOS), the Integrated Global Observing Strategy (IGOS), the Space Frequency Coordination Group (SFCG) and the International Precipitation Working Group (IPWG).

4. Structure

The WMO Space Programme functions on global, regional and national levels. It involves the design, implementation and further development of the operational meteorological and R&D satellites comprising the space-based components of the GOS, GAW, GCOS and WHYCOS into an integrated global system of environmental satellites. The integrated global system of environmental satellites, consisting of facilities and arrangements for making observations at stations on land and at sea, and from aircraft, meteorological and Research and Development satellites and other platforms. The space based components of the GOS, GAW, GCOS and WHYCOS consist of:

(a) Operational satellites
Geostationary
Polar orbiting

(b) Research and Development satellites

6. Education and Training

The WMO Space Programme is responsible for Education and Training in the use and applications of satellite data, product and services from both operational meteorological and R&D satellites.

7. Frequency allocations

The WMO Space Programme is responsible for protecting and managing radio-frequencies for meteorological activities for both operational meteorological and R&D satellites by pursuing WMO's requirements for stable, long-term allocations of suitable radio-frequency bands for its specific needs in close coordination with the related activities of ITU and with Members.

8. Codes & data formats

9. Communications
Direct broadcast
Alternative delivery means

10. Data collection

11. Ground segment
(Operational and R&D)

12. WMO Supported Programmes
World Weather Watch
JCOMM
WCP
GCOS
WCRP
AREP
Hydrology and Water Resources Programme
Education and Training Programme
Technical Cooperation Programme

ANNEX IV

GCOS Observing Principles

In establishing observing systems for climate, GCOS has identified a number of basic principles that should be followed. These derive from the so-called Karl principles (which have also been adopted by the Parties to the UN Framework Convention on Climate Change) and can be summarized as:

- ensure overlap whenever instruments are changed;
- fully document data processing methods;
- fully document station histories;
- maintain long continuous records;
- maintain calibration and validation facilities;
- wherever possible, back-up 'high-technology' systems with 'low-technology' ones;
- ensure that any new facilities fill real gaps;
- maintain effective data archive and access facilities;
- ensure there are processes to transfer systems from research to long-term stable operations;
- include GCOS needs in the initial design of networks.

These principles need to be applied to both *in situ* and satellite systems. A recent review by a USA National Research Council (NRC) Panel highlighted the following issues for the application of satellite data for climate purposes:

- rigorous station keeping;
- overlapping observations;
- launch-on-schedule strategy;
- rigorous pre-launch and on-board calibration;
- formal production of climate products;
- web access to metadata;
- use of functioning baseline instruments on de-commissioned satellites;
- need for complementary *in situ* baseline observations;
- web access to basic climate products;
- need for network monitoring.

An additional requirement, especially for geostationary data, is the archiving of the key raw data for delayed-mode analysis.