CGMS - THE CHANGING LANDSCAPE

Populations and economies around the world are becoming ever more sensitive to the impact of weather and climate, and this results in steadily increasing demands being placed on meteorological services. One component is the demand for more accurate weather forecasting and timely warnings for the protection of life, health, property and infrastructure, and also from a variety of weather-sensitive sectors of the economy (e.g. transport, agriculture, energy, insurance, tourism, health, etc.). Another component is the need for improved data records to develop climate services (e.g. within the Global Framework for Climate Services) to better understand, monitor and predict climate change and variability, in support of impact assessments and definition of mitigation and adaptation policies.

Satellites are now the dominant source of observational inputs to Numerical Weather Prediction models, with higher impact on forecast skills than conventional observations, and are also essential for climate monitoring at a global scale. Therefore the evolving demand is placing new and more stringent requirements on meteorological satellite systems (e.g. enhanced spectral, spatial and temporal resolution, accuracy, timeliness of data delivery and strict service continuity) as highlighted in the evolution of national space policies[1] and in the strategies of meteorological satellite operators[2].

The deployment of new generations of meteorological satellite systems, with enhanced instrumentation and much higher data rates, is already partially underway, resulting in much higher impact on forecast accuracy than heritage systems, with further improvements expected in the medium term as new systems become available in orbit. Their deployment needs to be carefully coordinated in the longer term in order to reap the maximum benefit for the worldwide user communities, whilst minimising overall costs and data gaps.

Decisions on programmes that are still in the planning phase, sometimes prove to be more challenging with the economic crisis in some parts of the world, resulting in schedule uncertainties and threats to the availability of some key elements of the space-based component of the WMO Integrated Global Observing System (WIGOS). Indeed, resource constraints are even affecting some of the most traditionally reliable pillars of the WIGOS. To minimise the effects of any potential gaps, enhanced international coordination and cooperation, is more than ever required to provide a balanced sampling of the global atmosphere, ocean and land surfaces. This is particularly true in Low Earth Orbit where the value of observations from a particular satellite is critically dependent on its observational context, i.e. the availability of instruments on other satellites in different orbits. Also, a coordinated approach is pivotal for the long-term coverage of the "geostationary ring" and for the provision of sustained observations currently available only on a best-effort basis or from R&D

[1] National Space Policy of the United States of America, June 28, 2010
China's Space Activities in 2011, White Paper, Beijing, December 2011

[2] EUMETSAT Strategy; http://www.eumetsat.int/groups/cps/documents/document/pdf_br_cor02_en.pdf

missions. Indeed, the optimum use of operational and R&D assets of CGMS members should make it possible to guarantee timely access to data on a global scale, and minimise risks of critical data gaps, through enhanced international coordination and cooperation. This represents a particularly valuable opportunity in the current difficult economic circumstances.

From a climate monitoring perspective, a fundamental building block for the provision of climate services is the Architecture for climate monitoring from space, and its associated repository of climate data records. Again, the holdings of long series of satellite observations of CGMS members, the long-term programmatic perspective of operational programmes and the bridge and synergy with R&D missions, are outstanding assets which need to be coordinated at international level if the optimum overall contribution to all functions of the Architecture is to be delivered, in compliance with GCOS requirements and expectations from decision-makers.

As regards data dissemination, higher data rates resulting from the new meteorological systems also call for increased coordination of the introduction of new, more capable, flexible and efficient dissemination systems and services to users worldwide.

These few examples underscore the need for CGMS to continue to promote international cooperation and to play a central coordination role by striking an appropriate balance between unavoidable constraints, operational risks and opportunities, using optimally the satellite resources available for the maximum benefit to the user communities, in particular in the areas of Numerical Weather Prediction and Climate Services.

It should be noted that, with the exception of the increasing focus on climate services, the emerging challenges for CGMS are generally similar in nature to those successfully addressed in the past - see Annex I on CGMS past achievements - and so the structures and methodologies established by CGMS are probably well-suited for current coordination requirements.

Therefore, it is believed that the future essentially calls for tailoring and setting new coordination priorities, and a High Level Priority Plan with a 3-5 year perspective has been developed for that purpose (see Annex II). This plan has its origins in a decision taken at CGMS-39 and, followed by a meeting of the CGMS Task Force on Restructuring in January 2012, and extensive consultation with CGMS Members. The plan is a living document and will be updated annually and presented at CGMS plenary for endorsement. The high priority issues identified will be used to both structure the discussions at the CGMS Plenary and guide the activities of the CGMS Working Groups.

ANNEX I: CGMS TECHNICAL ACHIEVEMENTS

The key technical achievements of CGMS, since its inception in 1972, are summarised in the following sections.

1. Establishment of a global baseline for geostationary coverage

The initial focus of CGMS upon its creation, and reflected in its former name of "Coordination of Geostationary Meteorological Satellites", was to ensure complete coverage of the geostationary ring by agreeing on five fixed locations (135°W, 75°W, 0°, 76°E, 140°E) to be implemented by the USA, Europe, Russia, and Japan respectively, with agreed target capabilities. This agreement followed the successful demonstration constituted by the First Global GARP Experiment (FGGE). The geostationary constellation is no longer the unique scope of CGMS, which now also addresses LEO coverage, but geostationary coverage remains a major priority for CGMS. Since this initial agreement, the geostationary baseline has evolved, with additional locations, more partners, and more advanced payload standards.

2. Establishment of a global back-up framework (contingency planning)

The CGMS Global Contingency Plan was conceived as a way of maximising the continuity of satellite-based meteorological information services by sharing in-orbit satellite redundancy in a globally-coordinated manner through a "help-thy-neighbour" approach.

In practice this Global Contingency Plan defines a framework for implementing a set of regional contingency arrangements that govern the support to be provided by agencies operating satellites in neighbouring geostationary slots in the event of a satellite failure that cannot be resolved by the inherent redundancy of the particular system.

In developing this plan, CGMS has played a key role by:

- Defining priority requirements, in conjunction with WMO, and criteria for launching contingency actions;
- Establishing appropriate guidelines and best practices;
- Facilitating and monitoring the creation of regional contingency arrangements;
- Providing a forum, within its Working Group on continuity and contingency, for evaluating the need and scope of possible contingency actions.

Examples where such bi-lateral regional contingency arrangements have already been implemented include:

- From 1985 to 1988 NOAA repositioned its GOES-4 spacecraft to fill a gap over Europe created by the loss of the Data Collection Service on Meteosat-2;

- From 1991 to 1995 EUMETSAT re-positioned Meteosat-3 over the Atlantic to provide a back-up to GOES-7 (ADC and XADC);
- In 1992 JMA made available GMS-4 for Data Collection on a GOES International Data Collection channel;
- From 1998 EUMETSAT deployed a back-up Meteosat spacecraft over the Indian Ocean (initially as a back-up for GOMS);
- In 1998, NOAA and EUMETSAT signed the Initial Joint Polar System Agreement (IJPS). Within the IJPS exchanged instruments, coordinates NOAA and EUMETSAT polar-orbiting satellite systems and their respective ground segments and significantly improves data coverage for critical weather forecasting applications and future climate user services.

- From 2004 to 2005 NOAA relocated GOES-9 following the retirement of JMA's GMS-5, and until the availability of MTSAT-1.

These contingency actions have had a dramatic effect on the availability of satellite data, with the consequential benefits to the user community.

3. Optimisation of the GOS and response to the WMO Vision for the Space-based GOS in 2025

CGMS has provided advice to WMO for the definition of the space-based component of the WMO Vision of the Global Observing System in 2025, addressing both the needs of meteorology and climate monitoring, and has developed a CGMS response to this vision. This response, presented as the "CGMS baseline for the operational contribution to the GOS" is an essential tool for ensuring that the individual efforts of the various space agencies are deployed in a coordinated and efficient manner to respond to the observational requirements.

This response is being implemented in a stepwise manner, through regular updates to the CGMS baseline.

4. Standardisation of data dissemination formats and coordinated planning for the analogue to digital transition

CGMS has taken a lead role in initiating, and obtaining convergence on, coordinated dissemination formats for Low Rate Image Transmission (LRIT - the digital successor to analogue WEFAX transmissions) and High Rate Image Transmission (HRIT) for geostationary systems, and for Low Resolution Picture Transmission (LRPT) and High Resolution Picture Transmission (HRPT) for LEO systems. Such coordinated dissemination formats are key elements in simplifying the processing of image data from multiple sources, especially for LEO systems that have a global user base, as well as assisting any contingency arrangements between satellite operators for geostationary systems.

CGMS has also taken care to ensure that, when analogue transmissions were phased out, the users of this image data were given adequate time to prepare for the transition to digital LRIT broadcasts. Following discussion with satellite operators, the parallel operation of the two types of transmission were maintained for typically 2 or 3 years.

5. Development of a common standard for the International Data Collection System (IDCS)

The International Data Collection System (IDCS) is designed to support the collection of data from mobile Data Collection Platforms (e.g. on ships, ocean buoys, aircraft or balloons) which move from the telecommunications field of view of one geostationary spacecraft to another.
The standard for this important international system was created by CGMS and the performance of the system is regularly monitored at CGMS meetings. These arrangements have resulted in the smooth and continuous collection of this important environmental data.

6. Development of an integrated strategy for data dissemination

To respond to the challenge of increasing data rates from meteorological instruments, CGMS has spearheaded the development of an integrated strategy for data dissemination from meteorological satellites involving the complementary use of direct satellite broadcasts and alternative dissemination mechanisms (e.g. dissemination from third-party communication satellites and via the internet).

Such a strategy has been extremely successful in accommodating the dissemination of much greater data volumes, whilst at the same time greatly increasing access to data through the use of low cost, off-the-shelf, user reception systems.

The Integrated Global Data Dissemination System (IGDDS) is a direct result of the implementation of this strategy; with its interlinked regional direct broadcast systems providing near-global coverage.

The success of this dissemination system has resulted in it being extended to other application areas, and the IGDDS now provides the main components of the GEONETCast system that is used to disseminate data from GEOSS.

7. Coordination of Radio Frequency Allocations and Protection of Radio Frequencies

The radio frequency spectrum is a limited natural resource and vigilance is needed to protect meteorological satellite frequencies in both direct broadcast and sensor passive or active frequency ranges.

Frequency management issues are regularly discussed during CGMS meetings, at which coordinated approaches are agreed and then submitted by each individual member to its national frequency authorities of the individual members for approval. In addition, CGMS experts and members participate in the various meetings of the

ITU and World Radio Conferences to help ensure the agreed CGMS position is taken into consideration.

8. Development of a coordinated approach to calibration and inter-calibration

Through the exchange of information on calibration techniques between operators, CGMS has actively promoted 'best practices' for the operational calibration of meteorological products (on-board, vicarious and inter-calibration).

In conjunction with WMO, CGMS in 2005 also initiated the formation of a system dedicated to inter-calibration (GSICS). The objective of this system is to monitor, improve and harmonize the quality of observations from operational weather and environmental satellites, with the aim of ensuring consistent calibration among space-based observations worldwide for climate monitoring, weather forecasting, and environmental applications. Indeed GSICS has proved to be a very effective forum for CGMS meteorological satellite operators and CGMS R&D satellite organisations to work together on the development of appropriate calibration algorithms, and for the provision of reference calibration data.

9. Promotion and development of a coordinated framework for generating climate data records from space observations (SCOPE-CM)

In 2008 CGMS, in conjunction with WMO, took a leading role in the establishment of an international initiative, involving satellite processing centres distributed across the globe, to ensure the continuous and sustained provision of high-quality satellite products, on a global scale, related to the Essential Climate Variables defined by the Global Climate Observing System (GCOS) for climate monitoring.

Following the successful pilot phase of the initiative, SCOPE-CM is now entering its implementation phase, and the initial focus on five areas is being progressively expanded to address other thematic groupings.

10. Framework of scientific and technical collaboration for improving and harmonising key satellite products

CGMS attaches considerable importance to enhancing the utilisation and improving the quality of satellite products.

To this end, four international scientific working groups are supported by CGMS:

- the International TOVS Working Group (ITWG) focuses on satellite soundings;
- the International Winds Working Group (IWWG), established under the auspices of CGMS, addresses Atmospheric Motion Vectors (AMV) derivation the applications of AMVs, quality monitoring and other wind derivation techniques;
- the International Precipitation Working Group (IPWG) discusses the

improvement and harmonisation of satellite-based rainfall estimates;
the International Radio-Occultation Working Group (IROWG) addresses the contribution of the radio-occultation technique to observing the atmosphere.

These groups have made numerous contributions to improving the quality of satellite-derived products, and their deliberations are regularly reviewed at CGMS plenaries.

11. Facilitation of a common approach to archiving of data

Through the promotion of best operational practices, CGMS has made an important contribution to the long-term preservation of data, which is essential for climate monitoring applications.

12. Promotion of training in the use of meteorological and other satellite data and the development of the Virtual Training Laboratory

To promote the effective use of satellite data CGMS has been active on a number of fronts, including the shared production of training material between CGMS members and the development (in conjunction with WMO) of a Virtual Laboratory for Education and Training and Education in Satellite Meteorology (VLab).

This Virtual Laboratory now includes eight satellite operators and 12 Centres of Excellence around the world, enabling distance learning to be carried out in a controlled manner, with the participation of the meteorological satellite operators, and in all WMO languages. The VLab thereby helps improve the utilisation of satellite data, and at the same time making best use of the resources dedicated to education and training.

ANNEX II: HIGH LEVEL PRIORITY PLAN (HLPP)

1. INTRODUCTION

To support the efficient execution of CGMS's coordination role, the following high-level priority tasks have been identified with a horizon of typically 3-5 years. It is intended that these priority tasks will be used to guide the discussions of the CGMS Working Groups and Plenary, and will subject to a rolling review.

For convenience, the tasks are organised according to topic.

Furthermore, in order to ensure the availability of an appropriate framework for the execution of these high priority tasks, the main features of the CGMS Charter are hereby reaffirmed:

- The need to keep a clear focus on coordination of long-term and sustainable satellite systems relevant to weather and climate to which both operational and Research & Development (R&D) agencies can contribute;

- The need to keep a technical and scientific focus in CGMS discussions;

- The need to continue to respond to requirements from WMO (WIGOS and GFCS) and related international programmes (e.g. WCRP, GCOS, GOOS, GTOS, CEOS, ...).

2. HIGH PRIORITY TASKS (ordered by theme)

XX. Demonstrate and advocate the benefit of EO satellite missions.

Develop a credible methodology for assessing the socio-economic benefit of investment in EO satellite missions

- o Establish a CGMS Tiger Team on this issue who would collaborate with e.g. the WMO CBS and other partners and would report at CGMS-41.

Engage in communication and outreach activities to promote EO benefits

A. Coordination/Optimisation of Observing Systems

Coordinate the implementation of the CGMS baseline missions (updated nominal locations/orbits, operators), including ptimisation of the distribution of Low Earth Orbit (LEO) sun-synchronous orbits to ensure efficient temporal sampling of the atmosphere;

support satellite impact studies including regional verification;

urgently establish a tiger team to coordinate the technical evaluation of the global and regional impact of flying an FY-3 satellite in early morning orbit, in order to encourage and support CMA in their decision making process.

- Facilitate the evolution of demonstration missions to an operational status (where appropriate e.g. HEO missions);

- Investigate through IROWG how a coordinated and optimised system could be set up for radio occultation observations observations for atmosphere and ionosphere monitoring.

Identifying partnership opportunities on space and ground segments

– CGMS Members to assist NOAA in identifying potential sharing of ground assets in support of COSMIC-2
– Establish a CGMS coordinated mechanisms for hosted payloads, e.g. for solar wind monitoring.

Identify potential gaps and ensure appropriate contingency measures are in place including analysis of budget constraints and associated risk assessment.

B. Coordination/Optimisation of data collection systems

Coordinated participation in the activities of the International Forum of Users of Satellite Data Telecommunication Systems, to prepare the future use of the International Data Collection System (IDCS);

Assess Data Collection Platform (DCP) and Argos Data Collection System (A-DCS) status and evolutions including International channels, taking into account requirements of Tsunami alert systems and ocean observations (e.g. buoys)

CGMS to share lessons learnt and share experiences on certification of DCS platforms (especially HR platforms).
CGMS members to share information on the development of their High Rate Dissemination (HRD) platforms and share lessons learned on mitigating interference between DCPs

To confirm user requirements for sharing data/information delivered using DCS (outside the regional area). Data mechanisms to share DCP data.

C. Expanding the quality of satellite-derived data and Products

Establish within GSICS a fully coherent calibration of relevant satellite instruments across operational CGMS agencies, recognising the importance of collaboration with research CGMS agencies;

Establish commonality in the derivation of satellite products for global users where appropriate (e.g., through sharing of prototype algorithms);

Foster optimum the continuous improvement of products through validation and intercomparison through international working groups and SCOPE-type mechanisms;

Harmonise the metadata (e.g. quality descriptors) and format of products to be exchanged;

Develop, and start implementing, methods to describe the error characteristics of satellite data and products (taking benefit, where appropriate, the methods developed in the context of QA4EO carried out by CEOS in support of GEOSS);

Strengthen interaction with users in selected thematic areas by establishing a close relation with them as beta-testers and foster optimum use of satellite data.

continue to foster optimum use of satellite data for weather forecasting, climate applications, and environmental assessments including hazardous events such as volcanic ash and flooding.

D. Advancing the architecture for Climate Monitoring

Assess how CGMS can optimally contribute to the implementation of the GFCS by taking an active role in the construction of the Architecture for Monitoring Climate from Space:

Evaluate the CGMS baseline in the light of the logical view of the architecture

Extend the use of the Global Space-based Inter-Calibration System (GSICS) and the Sustained Co-Ordinated Processing of Environmental satellite data for Climate Monitoring (SCOPE-CM) frameworks.

Provide an analysis of data for specific phenomena (e.g. evolution of convection in the tropical belt based on 35 years of GEOstationary (GEO) observations);

- Establish priorities of ECVs with a time span of at least 20 years (including ECVs addressed by the International Science Working Groups) and contribute to creation of key FCDR that provide the basis for many ECVs.

Ensure the data holdings of CGMS members are appropriately reflected in the Architecture for Climate Monitoring from Space (physical view) through their systematic contributions to the Essential Climate Variable (ECV) Inventory;

Establish an integrated approach for accessing climate data records produced by CGMS members;

Promote a common approach to the long-term preservation of data through the exchange of information and the establishment of a coordinated consensus on best practice.

E. Data Dissemination, direct read out services and contribution to the WIS

Support the user-provider dialogue on regional/continental scales through regional coordination groups maintaining requirements for dissemination of satellite data and products through the various broadcast services;

Support the implementation of sustained, coordinated DVB satellite services for the Americas, Africa, Europe and the Asia Pacific regions;

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Increase access to, and use of, data from R&D and pre-operational missions;

Investigate the feasibility of introducing a coordinated dissemination service for meteorological information in helping to mitigate disasters;

Investigate the feasibility of introducing a coordinated dissemination service for information in support of the Ocean User Community;

Maintain the CGMS Direct Broadcast Global Specifications, optimise and harmonise the approach to direct read-out dissemination, whilst investigating possible alternatives

Evaluate the set of applicable (or TBD) standards for direct and other dissemination mechanisms in use by CGMS members and assess if there is a need, in view of future systems, to amend, modify or revise such standards (or to derive new ones).

;

Facilitate the transition to new direct readout systems (GOES-R, JPSS, FY-3);

CGMS members to work together to define a set of recommendations seeking affordable future receiving stations or alternatives to direct read-out solutions.

Further enhance the Regional ATOVS Retransmission Services (RARS) initiatives through their extension to advanced sounders;

All CGMS satellite operators to utilize operationally the WIS infrastructure for satellite data provision and discovery;

Provide coordinated CGMS inputs to WMO on satellite and instrument identifiers or data representation within the WIS (including the Regional Meteorological Data Communications Network).

F. Radio Frequency (RF) Protection

Establish a coordinated position on the future of L-band services;

Investigate how to mitigate Earth Exploration Satellite Service (EESS) X-band congestion and coordinate interference assessments

Interference assessments will be performed on a regular basis and as necessary.

Establish options for the sharing of the Ka-band spectrum (LEO and GEO systems);

Establish coordination mechanisms for sharing and using this band (both GEO and LEO systems and inter-agencies)

Facilitate an effective preparation of national World Radio Congress (WRC) positions favorable for the CGMS-related issues;

G. Preparation for new generations of operational satellites

Prepare operational users for the new generation of meteorological satellites through user readiness programmes, with implications for product generation, dissemination and user training, taking into account the “guidelines for ensuring user readiness for new generation satellites” adopted at CBS-XV.

H. Training

Harmonise the Virtual Laboratory for Education and Training and Education in Satellite Meteorology (VLab) training material, and training course delivery, to better reflect the trend towards similar/common instruments being, or to be, flown by CGMS Operators;

Update and develop new VLab training material where necessary, and in collaboration with partner institutions such as Collaboration among Education and Training Programmes (COMET) and Committee on Space Research (COSPAR);

Provide shared, regular support to funding the VLab Technical Support Officer function through a WMO Trust Fund, and to the VLab Centres of Excellence as per agreed expectations.

I. Space Weather

Establish a coordinated approach to the monitoring of space weather and the reporting of space weather-related spacecraft anomalies.

- **Assess how CGMS is organised to address space weather matters**.