CGMS

CGMS-42 WMO-WP-6
V1, 25 April 2014

Prepared by WMO
Agenda Item: C.6
Discussed in: Plenary

THE CGMS BASELINE IN THE WIGOS REGULATORY MATERIAL

HLPP reference: 1.1.1

ABSTRACT

The Manual on the WMO Integrated Global Observing Systems (WIGOS Manual) is part of the WMO Regulatory Material approved by WMO Members at Congress. It has to comply with certain drafting standards, highlighting the obligations of WMO Members (The members shall...) as opposed to the recommendations (Members should...), whilst background information is provided in "Notes" or Annexes.

Chapter 4 of this Manual is dedicated to “Common attributes specific to the space-based sub-system of WIGOS”. In order to reflect the agreement reached among CGMS satellite operators to ensure continuity of the space-based observing system, the decision was made to include the text of the CGMS Baseline as an annex to this chapter, with the understanding that subsequent updates of the CGMS Baseline would be implemented in further updates of the WIGOS Manual as appropriate.

Chapter 4 is contained in pages 50-56 of the draft Manual on WIGOS, followed by the CGMS Baseline on pages 57-59. These pages are reproduced in the present paper for information and comments.

Action/Recommendation proposed:

- CGMS members to note Chapter 4 of the draft WIGOS Manual, which is related to the space-based sub-system, and provide feedback to the WMO Secretariat (Iriishojgaard@wmo.int) by 30 June 2014.

WORLD METEOROLOGICAL ORGANIZATION

WMO INTEGRATED GLOBAL OBSERVING SYSTEM (WIGOS)

(20xx edition)

MANUAL on WIGOS

(Version 0.4)

DRAFT

NOTE: This extract includes only the space-based sub-system section, i.e. pages 50-56, with the CGMS baseline as an annex on pages 57-59.

4. COMMON ATTRIBUTES SPECIFIC TO THE SPACE-BASED SUB-SYSTEM OF WIGOS

4.1. Requirements

4.1.1 General

4.1.1.1 Members shall strive to develop, implement and operate a space-based environmental observing system in support of WMO Programmes as described in Attachment 4.1 to this section.

Note: The space-based sub-system of WIGOS is established through dedicated satellites, remotely observing the characteristics of the atmosphere, the earth and the oceans.

4.1.2 Observed Variables

4.1.2.1 This sub-system shall provide quantitative data enabling, independently or in conjunction with surface-based observations, the determination of the following variables:

(a) Three-dimension fields of atmospheric temperature and humidity;
(b) Temperature of sea and land surfaces;
(c) Wind fields at the ocean surface and aloft;
(d) Cloud properties (amount, type, top height, top temperature, and water content);
(e) Radiation balance;
(f) Precipitation;
(g) Lightning detection;
(h) Ozone concentration (total column and vertical profile);
(i) Greenhouse gas concentration;
(j) Aerosol concentration and properties;
(k) Volcanic ash cloud occurrence and concentration;
(l) Vegetation type and status;
(m) Flood and forest fire occurrence;
(n) Snow and ice cover;
(o) Ocean colour;
(p) Wave height, direction and spectra;
(q) Sea level and surface currents;
(r) Sea ice properties;
(s) Solar activity;
(t) Space environment (electric and magnetic field, energetic particle flux, electron density).

4.1.3 Observing performance requirements

4.1.3.1 Satellite operators providing observational data to WIGOS shall strive to meet, to the extent possible, the uncertainty, timeliness, temporal and spatial resolution, and coverage requirements of WIGOS as defined in the WIGOS Information Resource (WIR), based on the Rolling Requirements Review process described in Section 2 of this Manual.

Note 1: The term “satellite operators” is used in the Manual on WIGOS to refer to “Members or coordinated group of Members operating environmental satellites”.

Note 2: A coordinated group of Members operating environmental satellites is a group of Members acting jointly to operate one or more satellites through an international space agency such as the European Space Agency or EUMETSAT

Note 3: These requirements are recorded and maintained in the requirements database: http://www.wmo.int/oscar.

4.1.4 Global planning

4.1.4.1 Satellite operators shall cooperate to ensure that a constellation of satellite systems is planned and implemented to guarantee the continuous provision of space-based observations in support of WMO Programmes.

Note: Collaboration is pursued within the Coordination Group for Meteorological Satellites, which includes all Members operating space-based observation systems in support of WMO Programmes.

4.1.5 Continuity

4.1.5.1 Satellite operators working together under the auspices of the Coordination Group for Meteorological Satellites or otherwise, should ensure the continuity of operation, and of the data dissemination and distribution services of the operational satellites within the sub-system through appropriate contingency arrangements and re-launch plans.

4.1.6 Overlap

4.1.6.1 Satellite operators should ensure an adequate period of overlap of new and old satellite systems in order to determine inter-satellite instrumental biases and maintain the homogeneity and consistency of time series observations, unless reliable transfer standards are available.

4.1.7 Interoperability

4.1.7.1 Satellite operators shall achieve the greatest possible interoperability of their different systems.

4.1.7.2 Satellite operators shall make available sufficient technical details about the instruments, data processing, transmissions, and the dissemination schedules for Members to fully exploit the data.

4.2. Design, planning and evolution

Note: The space-based sub-system is composed of:

a. An Earth observation space segment;

b. An associated ground segment for data reception, dissemination, and stewardship;

c. A user segment.

4.2.1 Space segment architecture

Note: The overall architecture of the space segment is described in Attachment 4.1.

It is defined and evolves in consultation with the Coordination Group for Meteorological Satellites. It includes:

- A constellation of geostationary satellites;
- A core constellation of sun-synchronous satellites distributed over three separated orbital planes;

- Other operational satellites operated on either sun-synchronous orbits or other appropriate Low-Earth orbits;
- Research and Development satellites on appropriate orbits.

4.2.2 Space programme life cycles

4.2.2.1 Satellite operators shall consider a trade-off between the need for a long series to pay-off the development cost and the user learning curve, on one hand, and the need to develop a new generation in order to benefit from state-of-the-art technology, on the other hand.

Note 1: The development of an operational satellite programme is conducted in several phases including: user requirements definition, feasibility assessment at system level, preliminary design, detailed design, development and testing of the subsystems, integration of all subsystems, system testing, launch campaign, and on-orbit commissioning. The overall duration of these development phases is typically of the order of 10 to 15 years.

Note 2: The exploitation phase for an operational programme including a series of recurring satellites is typically of the order of 15 years.

4.3. Instruments and Methods of Observation

Note 1: Space-based observation relies on a wide range of sensor types, e.g. active or passive, operating in various spectral ranges, with various scanning or pointing modes. Information on the principles of Earth Observation from space, the different types of space-based instruments and the derivation of geophysical variables from space-based measurements can be found in the Guide to Instruments and Methods of Observation, (WMO-No. 8), Part III.

Note 2: Detailed characteristics of current and planned systems of environmental satellites are available in the satellite module of the Observing System Capabilities Analysis and Review tool (OSCAR), which is available on line (http://www.wmo.int/oscar/space). It also contains an indication of the main instruments that are relevant for each specific variable observable from space, with their potential performance for the respective variables.

4.3.1 Calibration and Traceability

4.3.1.1 Satellite operators shall perform a detailed instrument characterization before launch.

Note: Members must strive to follow the pre-launch instrument characterization guidelines recommended by the Global Space-based Inter-calibration System.

4.3.1.2 After launch, satellite operators shall calibrate all instruments on a routine basis against reference instruments or calibration targets.

Note 1: Advantage should be taken of satellite collocation to perform on-orbit instrument inter-comparison and calibration.

Note 2: Calibration must be done in accordance with established methodologies as documented by the Global Space-based Inter-calibration System and the CEOS Working Group on Calibration and Validation.

4.3.1.3 Satellite operators shall ensure traceability to SI according to international approved standards.

Note: The Implementation Plan for the Global Climate Observing System (WMO/TD-1253) calls for sustained measurement of key variables from space traceable to reference standards, and recommends implementing and evaluating a satellite climate calibration mission.

4.3.1.4 To ensure traceability to SI, satellite operators shall define a range of ground-based reference targets for calibration purposes.

4.4. Space Segment Implementation

4.4.1 Operational satellites on Geostationary Earth Orbit

4.4.1.1 Satellite operators should implement an operational constellation of satellites in geostationary orbit as described in Attachment 4.1.

4.4.1.2 Satellite operators shall ensure that the constellation of satellites in geostationary orbit provides full disc imagery at least every 15 minutes, throughout a field of view between 60° S and 60° N.

Note: This implies the availability of at least six operational geostationary satellites if located at evenly distributed longitudes, with in-orbit redundancy.

4.4.1.3 Satellite operators should implement rapid-scan capabilities where feasible.

4.4.1.4 For the imagery mission in geostationary orbit, satellite operators should ensure an availability rate of rectified and calibrated data of at least 99 percent as a target.

4.4.1.5 To meet the essential requirement for continuity of data delivery, satellite operators, shall strive to implement contingency plans, involving the use of in-orbit stand-by flight models and rapid call-up of replacement systems and launches.

4.4.2 Core operational constellation on sun-synchronous Low Earth Orbits

4.4.2.1 Operators of LEO satellites should implement a core operational constellation of satellites in three regularly distributed sun-synchronous orbits as described in Attachment 4.1.

4.4.2.2 Operators of the core constellation of environmental LEO satellites on three sun-synchronous orbital planes in early morning, mid-morning and afternoon orbit, shall strive to ensure a high level of robustness allowing the delivery of imagery and sounding data from at least three polar orbiting planes, on not less than 99 percent of occasions.

Note: This implies provisions for a ground segment, instrument and satellite redundancy, and rapid call-up of replacement launches or on orbit spares.

4.4.3 Other capabilities on sun-synchronous Low Earth Orbits

4.4.3.1 Operators of environmental LEO satellites should implement capabilities in appropriate orbits as described in Attachment to the section.

4.4.4 Research and Development satellites

4.4.4.1 Operators of Research and Development satellites shall consider providing the following observing capabilities:

(a) Advanced observation of the parameters necessary to understand and model the water cycle, the carbon cycle, the energy budget and the chemical processes of the atmosphere;

(b) Pathfinders for future operational missions.

Note: For WMO, the main benefits of Research and Development satellite missions are:

- Support of scientific investigations of atmospheric, oceanic, and other environment related processes,
- Testing or demonstration of new or improved sensors and satellite systems in preparation for new generations of operational capabilities to meet WMO observational requirements.

4.4.4.2 Members shall strive to optimize the usefulness of observations from Research and Development satellites for operational applications. In particular, operators of Research and

Development satellites shall make provisions, where possible, to enable near-real time data availability to promote the early use of new types of observations for operational applications.

Note 1: Although neither long-term continuity of service nor a reliable replacement policy are assured, research and development satellites provide, in many cases, observations of great value for operational use.

Note 2: Although they are not operational systems, Research and Development satellites have proven to support operational meteorology, oceanography, hydrology and climatology substantially.

4.5 Ground Segment Implementation

4.5.1 General

4.5.1.1 Satellite operators shall make observational data available to Members over the WMO Information System (WIS) in accordance with the provisions in the Manual on the WMO Information System (WMO-No. 1060). Satellite operators shall inform Members of the means of obtaining these data through catalogue entries and shall provide sufficient metadata to enable meaningful use of the data.

4.5.1.2 Satellite operators shall implement facilities for the reception of remote-sensing data (and Data Collection System data when relevant) from operational satellites, and for the processing of quality-controlled environmental observation information, with a view of further near-real time distribution.

4.5.1.3 Satellite operators shall strive to ensure that data from polar-orbiting satellites are acquired on a global basis, without temporal gaps or blind orbits, and that data latency meets WMO timeliness requirements.

4.5.2 Data dissemination

4.5.2.1 Satellite operators shall ensure near-real-time data dissemination of the appropriate data sets, per the requirement of Members, either via an appropriately designed ground segment, by direct broadcast, or by re-broadcast via telecommunication satellites.

4.5.2.2 In particular, operators of operational sun-synchronous satellites providing the core meteorological imagery and sounding mission should ensure inclusion of Direct Broadcast capability as follows:

(a) Direct broadcast frequencies, modulations, and formats should allow a particular user to acquire data from either satellite by a single antenna and signal processing hardware. To the extent possible, the frequency bands allocated to Meteorological Satellites should be used.

(b) Direct broadcast shall be provided through a high data rate stream, such as the High Resolution Picture Transmission (HRPT) or its subsequent evolution, to provide meteorological centres with all the data required for numerical weather prediction (NWP), Nowcasting, and other real-time applications;

(c) If possible, a low data rate stream should also be provided, such as the Low Rate Picture Transmission (LRPT), to convey an essential volume of data to users with lower connectivity or low-cost receiving stations.

4.5.2.3 Satellite operators shall consider implementing re-broadcast via telecommunication satellites to complement and supplement direct broadcast services, to facilitate access to integrated data streams including data from different satellites, to non-satellite data and to geophysical data products.

4.5.3 Data Stewardship

4.5.3.1 Satellite operators shall provide full descriptions of all processing steps taken in the generation of satellite data products, including algorithms, characteristics, and outcomes of validation activities.

4.5.3.2 Satellite operators shall preserve long-term raw data records and ancillary data required for their calibration, reprocessing as appropriate, with the necessary traceability information to achieve consistent Fundamental Climate Data Records.

4.5.3.3 Satellite operators shall maintain Level 1B satellite data archives including all relevant metadata pertaining to the location, orbit parameters and calibration procedures used.

4.5.3.4 Members shall ensure that their archiving system is capable of providing on-line access to the archive catalogue with a browsing facility, provides adequate description of data formats, and will allow users to download data.

4.5.4 Data collection systems

4.5.4.1 Satellite operators with a capability to receive data and/or products from Data Collection Platforms (DCP) shall maintain technical and operational co-ordination under the auspices of CGMS in order to ensure compatibility.

4.5.4.2 Satellite operators shall maintain a number of “international” DCP channels identically on all geostationary satellites to support the operation of mobile platforms moving across all individual geostationary footprints.

4.5.4.3 Satellite operators shall publish details of the technical characteristics and operational procedures of their data-collection missions, including the admission and certification procedures.

4.5.5 User Segment

4.5.5.1 Operators of research and development satellites shall implement capabilities enabling Members to access the data in one of the following ways: via downloading data from server(s), via receiving data from a re-broadcasting service, or via receiving from a direct broadcast capability.

4.5.5.2 Members shall endeavour to install and maintain in their territory at least one system enabling access to digital data from both LEO and geostationary operational satellite constellations, either a receiver of re-broadcast service providing the required information in an integrated way, or a combination of dedicated direct readout stations.

4.5.5.3 Where appropriate, Members should strive to utilize fixed or moving DCP systems (for example to cover data-sparse areas) to take advantage of the data-collection and relay capability of the environmental observation satellites.

4.6. Observational Metadata

4.6.1 For each space-based system they operate, satellite operators shall record, retain and make available observational metadata in accordance with the provisions of section 2.5.

4.7. Quality Management

4.7.1 Quality Indicators

4.7.1.1 Satellite operators shall include appropriate quality indicators in the metadata for each datasets, in accordance with the provisions of section 2.5.

4.8. Capacity Development

4.8.1 Centres of Excellence

4.8.1.1 Satellite operators, and other Members having the capability to do so, shall provide support to education and training of instructors in the use of satellite data and capabilities e.g. at specialized Regional Meteorological Training Centres or other training institutes designated as Centres of Excellence in satellite meteorology, in order to build up expertise and facilities at a number of regional growth points.

4.8.2 Training strategy

4.8.2.1 Satellite operators should focus their assistance, to the extent possible, on one or more of these Centres of Excellence within their service areas and contribute to the Virtual Laboratory for Training and Education in Satellite Meteorology.

Note: The aim of the Education and Training strategy implemented through the Virtual Laboratory is to systematically improve the use of satellite data for meteorology, operational hydrology, and climate applications, with a focus on meeting the needs of developing countries.

4.8.3 User preparation for new systems

4.8.3.1 In order to facilitate a smooth transition to new satellite capabilities, satellite operators should make provisions for appropriate preparation of the users through training, guidance to necessary upgrades of receiving equipment and processing software, and information and tools to facilitate the development and testing of user applications.

4.8.3.2 In addition to working through the Virtual Laboratory, Members should, as appropriate, exploit partnerships with organizations providing education and training in environmental satellite applications, depending on their specific needs.

4.8.4 Engagement between Users and Data Providers

4.8.4.1 In order to achieve the most effective utilization of satellite data, Members should pursue the close engagement between users and data providers at a regional level.

4.8.4.2 Working with their regional association, Members should follow systematic steps to document the regional requirements for satellite data access and exchange.

ATTACHMENT 4.1

CGMS BASELINE FOR THE OPERATIONAL CONTRIBUTION TO THE GOS

(adopted by CGMS-39 on 6 October 2011)

FUTURE SATELLITE MISSIONS TO BE PERFORMED ON OPERATIONAL/SUSTAINED BASIS

Introduction

In support of the programmes coordinated or co-sponsored by WMO for weather and climate, CGMS Members plan to maintain the operational capabilities and services described below, that constitute the "CGMS baseline for the operational contribution to the GOS".

While this particular document focuses on missions that are decided and managed in an operational or sustained framework, with a perspective of long-term follow-on, this in no way precludes the importance of other missions undertaken e.g. on a research or demonstration basis. First of all, because today's research and development are the foundation of tomorrow's operational missions. Furthermore, because many missions initiated in an R&D framework for a limited duration are eventually extended well beyond their design life time and provide longstanding support to both scientific and operational activities.

This baseline defines a constellation of geostationary satellites, a core meteorological mission on three sun-synchronous orbits, other missions in sun-synchronous orbits, missions in other Low Earth Orbits, and contains cross-cutting considerations on contingency planning, inter-calibration, data availability and dissemination.

I. Constellation in geostationary orbit

At least six geostationary satellites shall be operated at evenly distributed locations with in orbit redundancy, and perform the following missions:

(a) Advanced visible and infrared imagery (at least 16 spectral channels, 2km resolution) over the full disc at least every 15 minutes
(b) Infrared sounding (hyperspectral on some positions)
(c) Lightning detection
(d) Data collection
(e) Space environment monitoring

On selected positions, the following missions shall be performed:

(f) Earth Radiation Budget monitoring
(g) High spectral resolution UV sounding
(h) Solar activity monitoring

II. LEO sun-synchronous missions

Operational sun-synchronous satellites shall be operated around three orbital planes in mid-morning ("am", nominally 09:30 descending, 21:30 ascending ECT), afternoon ("pm", nominally 13:30 ascending ECT) and early morning (nominally 05:30 descending, 17:30 ascending ECT) and, as a constellation, shall perform the following missions:

1) Core meteorological mission nominally on 3 orbital planes

(i) Multispectral visible and infrared imagery
(j) Infrared hyperspectral sounding (at least am and pm)
(k) Microwave sounding
(l) Microwave imagery

2) Other missions on sun-synchronous orbits

(m) Wind scatterometry over sea surfaces (at least two orbital planes)
(n) Ocean surface topography by radar altimetry (at least on am and pm orbits, supplemented by a reference mission on a high-precision, inclined orbit)
(o) Radio-occultation sounding (at least am and pm, supplemented by a constellation in specific orbits)
(p) Broadband VIS/IR radiometer for Earth Radiation balance (at least am and pm)
(q) Total Solar Irradiance (at least one)
(r) Contribution to atmospheric composition observations (at least am and pm)
(s) Narrow-band Vis/NIR imagers (at least one sun-synchronous, am spacecraft) for ocean colour, vegetation and aerosol monitoring
(t) High-resolution multi-spectral Vis/IR imagers (constellation of sun-synchronous satellites, preferably in am)
(u) IR dual-angle view imagery for high-accuracy SST (at least one am spacecraft)
(v) Particle detection and / or electron density (at least am and pm)
(w) Magnetic field (at least am and pm)
(x) Solar activity (at least two)
(y) Data collection

III. Other LEO missions

The following missions shall be performed on an operational basis by Low Earth Orbit satellites on appropriate orbits:

(z) Ocean surface topography by radar altimetry (A reference mission on high-precision, inclined orbit, complementing two instruments on sun-synchronous am and pm orbit)
(aa) Radio-Occultation sounding (dedicated constellation of sensors on appropriate orbits)

IV. Contingency Planning

The CGMS baseline is associated with contingency plans for geostationary and polar-orbiting satellite systems, which are detailed in the CGMS Global Contingency Plan[1].

V. Inter-calibration

Instruments should be inter-calibrated on a routine basis against reference instruments or calibration sites. The routine and operational intercalibration and corrections shall be performed in accordance with standards as agreed by the Global Space-based Inter-calibration System (GSICS).

VI. Data availability and dissemination

1 The Global Contingency Plan (http://www.wmo.int/pages/prog/sat/documents/CGMS_Global-Contingency-Plan_version2_070507.pdf) should be updated accordingly. It should indicate that in case of potential gaps on core sun-synchronous missions, absolute priority should be given to observation from mid-morning and early afternoon orbits, in order to maintain the continuity of these datasets.

VI.1. Data open availability with suitable timeliness

All operational environmental observation satellite systems should be designed to ensure the provision of data with suitable timeliness, as appropriate for their intended applications. Data should be preserved for the long term and documented with metadata allowing their interpretation and utilization. The satellite operators should establish dissemination contents and schedules that take into account the data requirements of users. Re-broadcast via telecommunication satellites should complement and supplement direct broadcast services, which allows cost-efficient access to integrated data streams including data from different satellites, non-satellite data and geophysical products. The dissemination systems should utilize all-weather resilient telecommunication means.

VI.2. Direct broadcast for core meteorological missions in LEO

The core meteorological satellite systems in LEO orbits, and other operational observation satellite systems when relevant, should ensure near-real-time data dissemination of imagery, sounding, and other real-time data of interest to Members by direct broadcast. Direct broadcast frequencies, modulations, and formats for polar-orbiting satellites should allow a particular user to acquire data from either satellite by a single antenna and signal processing hardware. Direct Broadcast should use allocations in all-weather resilient frequency bands.

VII. Note

The present update of the CGMS baseline is adopted in the light of satellite mission plans as they are known in October 2011.

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