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OPEN PROGRAMME AREA GROUP ON INTEGRATED OBSERVING SYSTEMS

EXPERT TEAM ON SATELLITE SYSTEMS

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GAP ANALYSIS OF SPACE MISSIONS

Satellite Observation Capabilities Review and Analysis Tool: Status and Open Issues

(Submitted by the Secretariat)

Summary and Purpose of Document

The information contained in the Dossier on the space-based Global Observing System (GOS) is being migrated to an online database. This database, which is related to space-based observing capabilities, will support the Rolling Requirements Review (RRR) process, together with the Observational Requirements Database and the future surface-based observing capabilities database.

Implementing this database meets the following objectives:

- Facilitating updating and ensuring information consistency
- Unifying information currently distributed in different forms and media
- Improving information accessibility through an online search interface
- Supporting monitoring the evolution of the space-based GOS
- Supporting Gap Analyses in support of the RRR.

The database, developed in MySQL, builds on the earlier development of the Observational Requirements Database by the WMO Space Programme office. The factual information on instruments and satellite programmes which is contained in Volumes 1 and 2 of the January 2012 issue of the Dossier has already been migrated and will be maintained in this new environment.

The Gap Analysis methodology used in Volume 3 of the Dossier has been reviewed, which has led to define two different functionalities:

- Evaluation of implementation progress of the GOS with reference to a baseline based on the Vision for the GOS in 2025, which replaces current Volume 3 of the Dossier;
- Gap Analysis for selected variables, which is a new functionality.

Options are being investigated for including the quantitative comparison of generic instrument performances with the requirements, which would basically replace Volumes 4 and 5 of the Dossier.

ACTION PROPOSED

The Expert Team is invited to note the progress made and provide guidance for the completion and further evolution of the Satellite Observation Capabilities Review and Analysis Tool.

SATELLITE OBSERVATION CAPABILITIES REVIEW AND ANALYSIS TOOL: STATUS AND OPEN ISSUES

1. BACKGROUND

As the Dossier on the Space-based Global Observing system (GOS-Dossier) has expanded along the years, with now more than 500 instrument descriptions and above 300 satellite missions quoted, it has become more and more important to ensure that this vast amount of information can be updated in a practical and consistent manner. This was the primary driver for migrating this information to a database of satellite capabilities, for internal use.

In addition, the Commission for Basic Systems (CBS) has adopted in 2010 a strategy for establishing a database in support of the Rolling Requirements Review (RRR) process, which should play a key role for the WMO Integrated Global Observing system (WIGOS). The database should include three components for user requirements, space-based capabilities, and surface-based capabilities respectively. It was initially considered that some of these components could be implemented and maintained by WMO Member organizations on behalf of WMO. No firm solution could however be found to implement this strategy. A first step was thus taken by the WMO Secretariat to implement the requirement database (www.wmo-sat.info/db) in 2011. Taking into account this successful experience, it was decided to expand the design of the internal database of satellite capabilities to include on-line consultation and gap analysis functionalities, which allows fulfilling the requirements identified by CBS. This approach builds on the technical environment of the requirements database and enables potential linkages between capabilities and requirements.

This development enables unifying different sets of information available within the Space Programme (600-page GOS Dossier, Satellite Status web pages, 200 html pages of instrument characteristics, internal spreadsheets on the evaluation of instruments and products), facilitating the maintenance and considerably improving the accessibility of this information.

Furthermore, the objective being to provide not only a repository of information on satellite instruments and programmes, but also a tool for reviewing and analysing these capabilities, the gap analysis methodology used in the GOS-Dossier has been reviewed. Particular attention was given to the distinction between *factual information*, to be maintained by the Secretariat with input from satellite operators, and *expert assessments*, which should be subject to review by relevant expert groups.

2. MAIN FUNCTIONALITIES OF THE DATABASE

2.1. Overview

The database currently includes the following functionalities:

- Online information on instruments and related satellites, agencies, and observed variables
- Online information on satellites and related instruments, agencies, and programmes
- Gap Analysis with respect to the capabilities of the “Vision for the GOS in 2025”
- Gap Analysis with respect to the measurement of selected variables
- Editing functionality.

The following information is recorded:

- Instrument acronym, instrument name, instrument definition, associated description, detailed spectral characteristics, providing agency;
- Satellite acronym, name, orbit type, altitude, equatorial crossing type, orbit inclination, launch date, end date, operating agency, programme, frequencies (to be added);
- Capabilities (of the Vision), geophysical variables, instrument type, instrument class.

An important feature of the data model is that each instrument is assigned to an instrument type and, within each type, to a performance class on the basis of detailed technical characteristics such as the number or width of its channels in specific portions of the spectrum. The performance class determines the relevance of an instrument to measure a particular variable, and to implement a particular capability of the Vision.

2.2. Instruments, satellites, programmes and agencies information

Purpose: to provide online access to factual information on instruments, satellites, programmes and agencies with user friendly search functions.

Source: information collected from satellite operators, primarily through the points of contacts designated within the Coordination Group for Meteorological Satellites (CGMS). The information received is cross-checked for consistency. When some inconsistency is detected, or when external information is used, confirmation is systematically sought with the relevant agencies.

Contents: the database currently contains records of 519 different instruments from 313 different satellites. This corresponds to the contents of Volumes 1 and 2 of the GOS-Dossier (with the exception of Annex 1 of Volume 1, containing the frequency plans of meteorological satellites, which remains to be added.)

Advantages:

- A considerable advantage of the database compared with the GOS-Dossier is that each piece of information being in principle unique, the updating process is much more straightforward; the workload is significantly reduced and any update is automatically reflected consistently throughout the database;
- Information can be searched by satellite, by instrument, by agency, or by keyword. Easy navigation is provided among these categories (For example from an instrument to a satellite flying it, then to the agency operating this satellite, or to the variables it can measure, then to the instrument type it belongs, and to other instruments of the same type). A temporal filter can be applied to focus the search on missions in orbit during a certain time period.
- The “Satellite status” web pages (http://www.wmo.int/pages/prog/sat/satellitestatus.php), which are maintained by WMO for CGMS, can be generated from this database in the future.

Table 1: List of Instrument types

Moderate-resolution optical imagers
High-resolution optical imagers
Cross-nadir scanning short-wave sounders
Cross-nadir scanning infrared sounders
Microwave radiometers
Limb sounders
Broadband radiometers
Solar irradiance monitors
GNSS radio-occultation sounders
Lightning imagers
Cloud and precipitation radar
Radar scatterometers
Radar altimeters
Imaging radar (SAR)
Lidar-based instruments
Solar activity monitors
Magnetometers

Electric field sensors
Space environment monitors
Gravimetric sensors

2.3. Gap Analysis with respect to the capabilities foreseen in the Vision for the GOS

Purpose: to provide graphical evidence of the current and planned implementation status of the space-based Global Observing System with reference to a baseline, and the related assessment of adequacy or potential gaps for the coming two decades. The baseline reflects the capabilities foreseen in the "Vision for the GOS in 2025.

Contents: this functionality of the database corresponds to Volume 3 "Gap Analysis" of the GOS Dossier. It identifies the instrument missions contributing to each of thirty-two items listed in the space-based part of the Vision of the GOS (See Table 2). For each capability, instruments are qualified by their class of performance for the said capability. A timeline is provided for the past and planned availability of each relevant instrument. For each capability, the observation strategy is recalled and an assessment of the plans is provided.

Table 2: List of Capabilities of the "Vision for the GOS in 2025"

GEOSTATIONARY SATELLITES	ATMOSPHERIC COMPOSITION IN APPROPRIATE ORBITS
Multi-purpose VIS/IR imagery from GEO	Cross-nadir short-wave spectrometry (for chemistry) from LEO
IR temperature/humidity sounding from GEO	Cross-nadir short-wave spectrometry (for chemistry) from GEO
Lightning imagery from GEO	Cross-nadir IR spectrometry (for chemistry) from LEO
POLAR-ORBITING SATELLITES	Cross-nadir IR spectrometry (for chemistry) from GEO
IR temperature/humidity sounding from LEO	Limb-sounding short-wave spectrometry
MW temperature/humidity sounding from LEO	Limb-sounding IR spectrometry
Multi-purpose VIS/IR imagery from LEO	Limb-sounding millimeter-submillimeter wave spectrometry
Multi-purpose MW imagery	
Sea-surface wind by active and passive MW	
DIFFERENT APPROPRIATE ORBITS	OPERATIONAL PATHFINDERS
Radio occultation sounding	Lidar-based missions
Radar altimetry	Low-frequency MW imagery
Imagery with special viewing geometry	MW temperature/humidity sounding from GEO
Ocean colour imagery from LEO	Ocean colour imagery from GEO
High-resolution imagery for land observation	Solid Earth (gravimetric sensors)
Cloud and precipitation profiling by radar	SPACE WEATHER
Earth radiation budget from LEO	Space Weather /Solar monitoring
Earth radiation budget from GEO	Space Weather /particle detection
Synthetic Aperture Radar	Space weather/Electric and magnetic field

Advantages:

In comparison with Volume 3 of the GOS Dossier, the baseline is better aligned with the capabilities foreseen in the Vision for the GOS in 2025 as approved by the WMO Executive Council (though in some cases a finer granularity had to be adopted, as for atmospheric composition being broken down in nadir/limb GEO/LEO IR/SW spectrometry). It also benefits from the possibility to apply filters e.g. on agencies, or instrument type, or on the time period, in order to narrow the analysis. Furthermore, in addition to these thirty-two pre-defined categories of missions, specific categories can be defined for study purposes.

Expertise:

Besides the factual information of the planned availability of particular satellites and instruments at particular times, this functionality involves the following types of expert information:

- The definition of an observation strategy, when such strategy is not fully defined in the Vision for the GOS in 2025;
- The prioritization of the various instrument classes with respect to their contribution to the observation strategy;
- The assessment of potential gaps with respect to the observation strategy, in light of the availability of relevant instruments over time.

2.4. Gap Analysis with respect to selected variables

Purpose: To provide graphical evidence of the planned availability of space-based sensors suitable for the measurement of particular geophysical variables, in support of a gap analysis. This applies to all 112 variables observed from space, among the 202 variables identified in the WMO Observational Requirements Database. The aim is to provide a first level of analysis, as an input for more detailed investigations.

Contents: The suitability of each relevant instrument is determined in a qualitative manner (primary instrument, very high relevance, high relevance, useful contribution, marginal contribution). A timeline is provided of the past and planned availability of each relevant instrument.

Advantages: Such a gap analysis is a new functionality with respect to the GOS-Dossier. The principle of relying on instrument classes rather than individual instruments has the following advantages:

(i) the relevance of each instrument for any particular mission is established on objective, scientifically supported, criteria ;
(ii) for any particular variable, different instruments having similar characteristics will automatically be qualified in a consistent manner.

Expertise Besides the factual information of the planned availability of particular satellites and instruments at particular times, this functionality involves the expert assessment of the relevance of each particular instrument type and class for each variable.

2.5. Editing functionality

The database is administered centrally by the Secretariat. Factual information will be regularly updated on the basis of information received by the Secretariat, including through the CGMS meetings. The expert part of the information will be submitted to ET-SAT for review, as was the case for the GOS-Dossier.

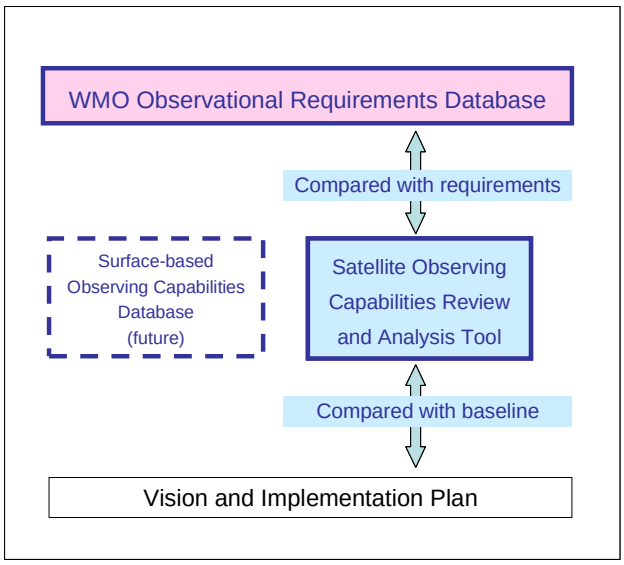
3. FUNCTIONALITIES PLANNED OR UNDER CONSIDERATION

It is planned to add the list of operational telecommunication frequencies (currently in Annex 1, Volume 1 of the GOS-Dossier) and to generate the "Satellite status" web pages, which are maintained by WMO for CGMS.

The inclusion of the quantitative evaluation of satellite system compliance with the user requirements, which would basically correspond to Volumes 4 and 5 of the GOS-Dossier, is under consideration. This would take advantage of the collocated Observational Requirements database. It is recalled that in the Dossier, this compliance is assessed on the basis of theoretical performances of generic, "representative" instruments. One approach would thus be to associate with each instrument type the "representative" performances determined in the GOS-Dossier Volume 4 and compare them with the requirements. This needs to be evaluated from the viewpoint of usefulness, relevance and maintainability.

4. CONCLUSION

Once completed and validated, the Satellite Observation Capabilities Review and Analysis Tool (tentatively named "SOCRAT") will significantly improve the accessibility, reliability and usefulness of the satellite information collected by the WMO Space Programme, in comparison with the GOS-Dossier. It is expected to be an important source of reference information. With the Gap Analysis functionality it should become a valuable tool for monitoring the evolution of the WMO Integrated Global Observing system (WIGOS) in complement to the requirements database and the future surface-based capabilities database (See Figure below).



Particular attention has been paid to identifying on one hand the factual objective information recorded in the database, and on the other hand the expert assessment, in order to provide full transparency on the Gap Analysis process. This tool is expected to provide useful support to the CGMS Working Group on Continuity and Contingency Planning, as well as to the physical definition of the Architecture for Climate Monitoring from Space.

In light of the demonstration that will be provided, the ET-SAT is invited to:

- Provide feedback on the overall design , contents, look and feel of this tool;
- Consider specifically the review and gap analysis functionalities;
- Provide guidance for the finalization, public release, and further evolution of this tool.

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