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VISION OF WIGOS SPACE-BASED COMPONENTS IN 2040

Development of a new vision

(Submitted by the Secretariat)

Summary and Purpose of Document

The document describes the scope of the “Vision of WIGOS space-based components” to be developed within the Rolling Review of Requirements (RRR). The RRR process comprises Observation Requirements, Statements of Guidance, a Vision of the observing system, and an Implementation Plan.

The contribution of ET-SAT is important to inform this process about the anticipated advances in space-based observation technology and the related opportunities to meet WMO needs in the future, specifically the 2025-2040 timeframe. The outcome of ET-SAT-9 should be provided by the end of 2014 to the Inter-Programme Expert Team on Observing System Design and Evolution (IPET-OSDE), which oversees the development of a new Vision. The new Vision will then be developed in 2015-2016, in consultation with interested parties, and submitted to the 16th session of the Commission for Basic Systems (CBS-16) in 2016.

The document firstly recalls the Vision of Global Observing Systems in 2025, which is currently in force, with suggestions already made to update this Vision.

With a view to open the discussion to novel ideas, a number of discussion items are then proposed in the following areas:

- Emerging and new requirements
- Consequences of observation-model linkage
- Advances in remote sensing approach
- New concepts of satellite systems
- Data access opportunities offered by future information technology
- Programmatic aspects and international coordination issues
- User engagement.

ACTION PROPOSED

- To discuss the issues mentioned in the document
- To formulate a statement as a contribution to the development of a vision of WIGOS space-based components in 2040.

VISION OF THE SPACE-BASED COMPONENTS OF THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM (WIGOS) IN 2040

1. BACKGROUND

1.1. Role of the Vision in the evolution of WMO global observing systems

The evolution of the WMO Global Observing System (GOS), and now the WMO Integrated Global Observing System (WIGOS) is driven by the so-called Rolling Review of Requirements (RRR) process which can be summarized as follows (See: http://www.wmo.int/pages/prog/www/OSY/GOS-RRR.html):

(i) Observation requirements are maintained by expert groups;
(ii) A Statement of Guidance is prepared for each application area to review the gaps and define priorities;
(iii) The Vision of the observing system defines a long-term goal for the evolution of observing systems in response to these Statements of Guidance;
(iv) The Implementation Plan provides a roadmap to reach this goal.

The Vision is updated typically every 8-10 years, while the requirements and the Statements of Guidance are regularly kept under review. The Implementation Plan and the progress made on implementation are updated accordingly.

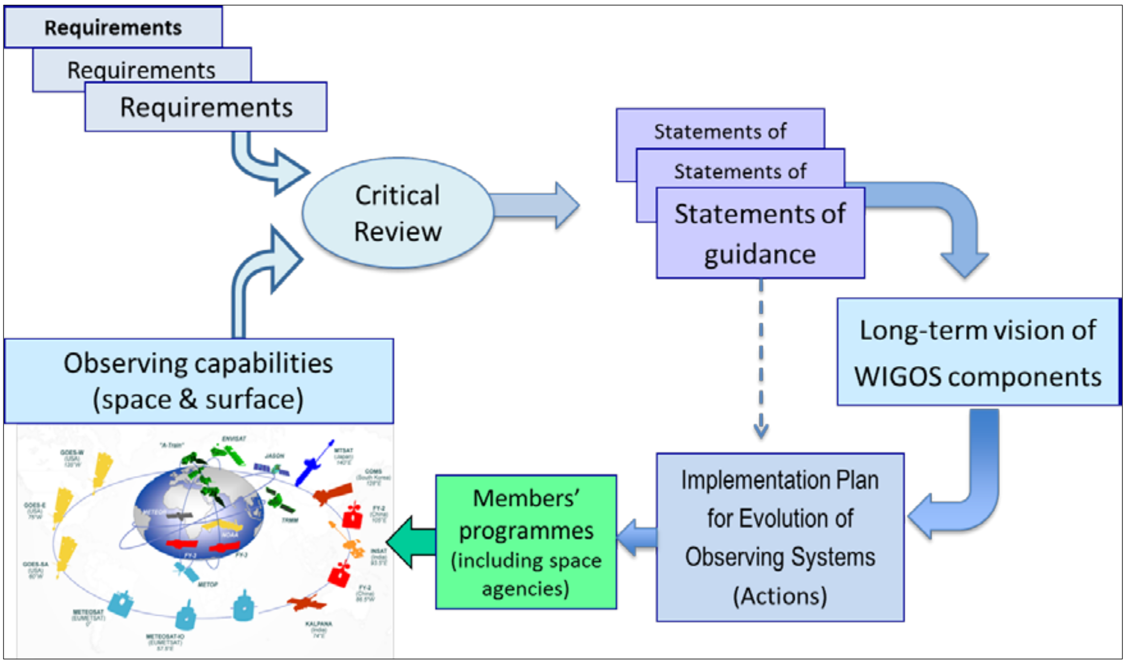

Figure 1: Schematic diagram of the RRR process

1.2. How the current vision for 2025 was initiated

The current "Vision of the Global Observing Systems in 2025" was initiated in response to the requirements of the "Satellite Supplement" to the GCOS Implementation Plan issued in October 2006. It was triggered by ET-SAT which highlighted that the GCOS requirements were not fully addressed in the Vision of the Global Observing System at that time (Vision for 2015, adopted in 2002) and therefore recommended that a new Vision be developed for 2025, at least for the space-based component.

The Implementation/Coordination Team on Integrated Observing Systems (ICT-IOS) reinforced this recommendation and the WMO Commission for Basic Systems (CBS) Extraordinary Session in Seoul, November 2006, agreed to develop a Vision of the Global Observing System in 2025 (surface- and space-based).

The space-based component of the Vision was developed in consultation with satellite operators (ET-SAT and CGMS) and user groups (ET-SUP, ITWG, user conferences) in 2007 and 2008. The Vision was endorsed by CBS-14 in Dubrovnik in February 2009 and approved by the Executive Council the same year. Two years later, following further discussions within ET-SAT and the Coordination Group for Meteorological Satellites (CGMS), CGMS adopted a “Baseline” which is the current response from CGMS to the WMO Vision. This “Baseline” has been acknowledged by WMO and incorporated in the draft Manual on WIGOS.

This is a good example of how ET-SAT can prompt a response to evolving requirements. The response cycle was relatively fast if we consider the number of consultations involved and the endorsement process by WMO constituent bodies (Note: the CBS holds regular sessions every 4 years) and by CGMS.

1.3. Decision to develop a new Vision to 2040

At its 8th meeting (ET-SAT-8), ET-SAT agreed that the current Vision should be kept under review, and “recommended initiating efforts towards developing a new Vision for submission to the next regular session of the CBS, in order to take into account new technological opportunities, emerging national capabilities, the outcome of the most recent impact studies and to adopt a longer time horizon e.g. 2040.” This was supported by the Inter-Programme Expert Team on Observing System Design and Evolution (IPET-OSDE) and the ICT-IOS in Spring 2014.

In September 2014, the CBS Extraordinary Session (CBS-Ext(14)) “*welcomed the initiative to develop a new Vision of WIGOS component observing systems in 2040. It encouraged IPET-OSDE, in consultation with ET-SAT, ET-SUP and other groups, to update the space-based component of the current Vision taking into account the advances in remote-sensing and satellite technology, the increasing maturity of space applications (e.g. to air quality, hydrology, and cryosphere monitoring), the diversity of orbits and mission concepts required for a balanced and robust space-based observing system.*“

2. DEVELOPMENT OF THE NEW VISION

2.1. Roadmap and milestones

a) Inputs will be collected from the various expert teams and application focal points by the end of 2014:

i) the focal points of Application Areas shall identify important requirements for their Application Areas that will not be met by the current Vision for 2025, and

ii) Teams responsible for particular observing technologies (<u>e.g. ET-SAT</u>) shall indicate observing system developments that may be possible during the period 2025-2040.

b) Based on these inputs, IPET-OSDE, with assistance from other Teams, will lead the preparation in 2015/2016 a "*Vision for WIGOS component observing systems in 2040*" to be proposed for consideration and endorsement by CBS-16 in fall 2016.

c) The current Vision for 2025 is underpinning the Implementation Plan for Evolution of Global Observing systems (EGOS-IP 2025), adopted by EC-65 in 2013, which remains in force until a new EGOS-IP is adopted in accordance with the new Vision.

2.2. Boundary conditions

- The new horizon should be 2040 in order to be ahead of currently firm satellite plans and have any chance to provide *guidance* at an early planning stage rather than just confirming the value of *existing* plans.
- The Vision shall be ambitious but achievable. The input from ET-SAT is crucial to evaluate what would be technically achievable by 2040.
- The new Vision should be in the context of the WMO Integrated Global Observing System (WIGOS). It shall include the World Weather Watch (weather), the Global Atmospheric Watch (atmospheric composition), the WMO Hydrological Global Observing System (hydrology). These observing systems include the WMO contribution to GCOS (climate) and – as concerns the space component – the observation part of the "Architecture for Climate Monitoring from Space". The future Global Cryosphere Watch, and the potential "Space Weather Watch" should also be included in the Vision.
- ET-SAT will focus its contribution on the space component, but the Vision itself will embrace surface and space observations.

2.3. Starting point

The current Vision for 2025 is available here:
http://www.wmo.int/pages/prog/sat/documents/SAT-GEN_ST-11-Vision-for-GOS-in-2025.pdf

Amendments to this current Vision for 2025 have already been proposed by various expert groups (See: http://www.wmo.int/pages/prog/www/OSY/Documentation/Vision2025.html) Examples of points which need be reviewed – already in a 2025 perspective – are:

- atmospheric composition : too vague definition of the observation strategy;
- radio-occultation: too conservative, ill-defined target;
- space environment monitoring: too vague approach;
- geostationary observation: unclear justification of the maximum interval between slots.

On those points, the current Vision reflects the state of minds 6 years ago but the progress made by the community should now allow devising a more precise strategy.

It was also pointed out that the current Vision was not visionary enough in the space component. This is not necessarily by lack of imagination, but rather because the scope of the Vision is to identify "challenging but achievable" goals. The capabilities that could be operationally achievable in 2025 were largely determined in 2009 given the lead time of research to operations transition and of operational programme decisions. Therefore, totally novel concepts would not have been achievable goals as operational components for 2025. Nevertheless some new concepts have been proposed as "operational pathfinders".

2.4. Towards a new Vision for 2040

ET-SAT is expected to analyze and propose changes to the vision resulting of the actual and anticipated advances in space-based observation technology, lessons learnt from demonstration missions, international context, etc.

There are thus two motivations for updating the vision:

- Recognition that some of the current targets for 2025 should be revised and updated, in the light of the latest plans and lessons learnt from demonstration missions; some updated targets for 2025 can thus be proposed (that might lead to amending the 2025 Vision if relevant)

- Extension to a new horizon (2040) which is assumed to be beyond what is determined by existing plans; new targets for 2040 must be proposed.

In extending the horizon to 2040, ET-SAT may wish to find a balance between the proposed missions responding to operational application requirements, and the promotion of new technologies that will pave the way for future operational missions.

3. ISSUES FOR CONSIDERATION

The following sections list a few issues for consideration by ET-SAT.

3.1. Emerging and new requirements

- On-going effort to specify space-based observation for atmospheric chemistry, including the growing needs to monitor greenhouse gases and air quality.

- Emerging potential of space capabilities to support hydrology (ground water, soil moisture, lake/river level, and precipitation), which deserves particular attention as water resources will become a critical issue at the global level, and the capabilities of space borne observation are not well known by the hydrology community.

- Increasing attention to the cryosphere, taking into account the activities of the Polar Space Task Group (PSTG) of the WMO EC Committee on Polar Observation, Research and Services (EC-PORS).

- Progress made in defining observation requirements for space weather; the fact that CGMS starts discussing space weather, and the Committee on Space Research (COSPAR) of ICSU is developing a roadmap for space weather.

3.2. Assimilation and reanalysis: consequences of observation-model linkage

Assimilation in NWP and coupled climate or environment models is to-day the most massive “user” of satellite data. Reciprocally, satellite data constitute by far the largest source of data ingested by these models. Feedback from NWP impact workshops regarding e.g. radio occultation, surface winds, atmospheric motion vectors may suggest new priorities.

- Assimilation acts as an efficient integrator of satellite data. Does it affect the priorities in designing the observing system, and how?

- For instance shall we grant increased importance to regular space and time sampling, stable error characterization, need for anchors to control the model bias, or emphasis on space and time resolution rather than radiometric resolution ?

- Use of data in reanalysis reinforces the need for data continuity (and quick retrieval of missing data in case of communication outage).

3.3. Remote-sensing approach

- What are the major advances in remote-sensing, telecommunications and satellite technology; that open new perspectives?

- Lessons learnt from R&D and demonstration missions since 2008 (e.g. SMOS) and progress in new plans (high eccentricity orbit, geostationary sounders, Doppler lidar).

- Are we taking proper advantage of all relevant measurement concepts:

    - Basic passive radiometry, hyperspectral passive radiometry
    - Multi-angle, polarimetric measurements
    - Radars, scatterometers, lidars
    - Radio-occultation, phase shift measurements
    - Sun/moon/star occultation
    - Doppler measurements
    - Particle detection
    - Accelerometry, distance ranging
    - Zeeman effect
    - What else ?

- MW passive and active remote sensing frequency protection issues

3.4. System aspects

- In orbit availability of (SI-traceable?) reference sensors (such as CLARREO) to serve as anchor for operational sensors, given the increasing need to ensure traceability of space-based observations, to improve interoperability, to provide anchors to NWP assimilation, and support climate change detection with high confidence; potential of HEO missions to provide calibration transfer standards for LEO instruments

- How shall we efficiently deal with the back-up concept ? As the observing system is getting more diversified (e.g. atmospheric temperature/humidity are measured by IR, by MW, by RO, plus surface-based measurements) it also gains in robustness since a gap in one data source tends to be compensated by the other sources in the NWP assimilation process.

- Taking an extreme case, can we imagine a fleet of small/cheap missions (e.g. Cubesat) that would be ready for filling gaps when one instrument fails aboard a multi-mission platform, until a full fledge payload can be re-launched ?

- Compared merits of HEO and LEO satellites to achieve high temporal coverage.

- Use of the International Space Station (decision process, payload environment)?

3.5. Data access strategy taking advantage of evolving Information Technology

- Data volumes and data rates generated by the satellites have been growing exponentially over the past 2 decades. In parallel, the telecommunication techniques have developed dramatically and enabled affordable dissemination solutions (e.g. DVB-S broadcast services since the late nineties, now DVB-S2). However, is this race leading to a sustainable regime?

- Thanks to improving connectivity globally, the online access to data servers belongs now to the range of operational near-real time access strategy. However not all the users have the necessary connectivity.

- Data security.

- Some WMO Members are left along the road: we need to offer a range of data access solutions. See the draft Data access strategy (WMO-WP-21 presentation to CGMS-42)

- Impact of “Cloud” technology and remote processing

- Trend to use higher frequencies for satellite downlink, with cost impact on the user

- Radio-frequency spectrum allocation and interference issues on telecommunication links (L-Band, C-Band..)

- Are data relay satellites an affordable option for Earth Observation programmes ? Can HEO satellites play this role, or a fleet of LEO, to achieve high timeliness?

3.6. Programmatic aspects

- The typical lifecycle of satellite programmes, including mission analysis and approval, design, development, manufacturing and operations, spans over several decades for operational satellite series. Is there a better model for flexibility and cost-efficiency ?

- How can we encourage optimization of global efforts through better complementarity and less duplication (except when justified to ensure robustness) to better fill the gaps? Bilateral cooperation agreements among space agencies to fly a specific instrument are part of the answer, and there are many successful examples.

- Faced with increasing political pressure in some countries to rely on private sector, how can we ensure that this trend does not undermine global data sharing and global mission coordination and harmonization ? Can we explore this concept without endangering the governmental programmes of vital importance ?

- EUMETSAT is a remarkable model of a large number of countries joining their resources to contribute in an integrated manner to the global system. The context is different in Asia where different countries are each running its own programme. Many other countries in the world don’t have the capability to run a space programme by their own, but could perhaps contribute to a collaborative undertaking. There are now discussions about an “African Space Programme”. How can we promote the participation of additional countries in the global space-based observing system in optimizing the overall effort and preserving the overall efficiency?

- Can we facilitate the engagement of additional countries who are not planning to run a full satellite programme by themselves, but who could contribute to a multilateral) framework (WMO or CGMS)? Would it make sense to think of a regional or global consortium of governmental shareholders, under private law (like e.g. CLS ARGOS, or EUMETNET)?

- Could such a consortium be a way to conciliate the advantages of governmental control and private management, if e.g. it purchased non-critical data to the private sector on a competitive basis (e.g. from radio-occultation sensors hosted on telecom satellites, or dedicated small satellites) without being constrained by the governmental or intergovernmental decision process cycles?

3.7. User engagement

User interaction is essential in order to understand the needs, to adapt the services to the needs, to provide feedback on the benefits of space missions, which justify the investment made.

In addition to the specific consultation and feedback mechanisms of each agency, WMO is encouraging or supporting the following user interactions:

- Regional user conferences by the satellite operators (AOSMUC, EUMETSAT Conference, EUMETSAT User Forum in Africa, NOAA Satellite Conference)
- Regional Requirements Coordination Groups (RAIDEG, RA3/4RCG, RAII WIGOS-PP, RA V-TTSUR)
- ET-SUP
- International Science Groups (IWWG,ITWG, IPWG, IROWG)

New/additional mechanisms ?

4. CONCLUSION

ET-SAT is invited to consider the questions above as a support for the development of its statement on the Vision of WIGOS space-based components in 2025-2040.