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COMMISSION FOR BASIC SYSTEMS
OPEN PROGRAMME AREA GROUP ON INTEGRATED OBSERVING SYSTEMS

EXPERT TEAM ON SATELLITE UTILIZATION AND PRODUCTS

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Vision for Satellite Utilization and Products in 2025

(Submitted by Luiz Machado and the Secretariat)

Summary and Purpose of Document

The scope of this draft Vision is to provide high-level goals for the utilization of satellite data and products in the coming decades in consistency with the Vision for the Global Observing System in 2025. The overarching goal is to enable users to take full advantage of satellite capabilities in the generation of services and knowledge addressing essential societal needs.

This Vision addresses the following areas:

- Timely availability of data
- Data quality assurance
- Tools for data processing and analysis
- Product generation
- User uptake, awareness and training
- Involvement of users and beneficiaries

ACTION PROPOSED

The sixth session is invited to note the draft Vision for Satellite Utilization and Products, and to provide comments as appropriate

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The Vision for Satellite Utilization and Products based on the Vision for the GOS in 2025

V1.0 (28 November 2011)

INTRODUCTION

Scope

The scope of this Vision is to provide high-level goals for the utilization of satellite data and products in the coming decades in consistency with the Vision for the Global Observing System (GOS) in 2025. The overarching goal is to enable users to take full advantage of satellite capabilities in the generation of services and knowledge addressing essential societal needs.

This document will present a vision of the evolving ways to use these different datasets in accordance with the Vision for the GOS in 2025. Different levels of activities downstream of the space-based observation will be considered (see figure 1).

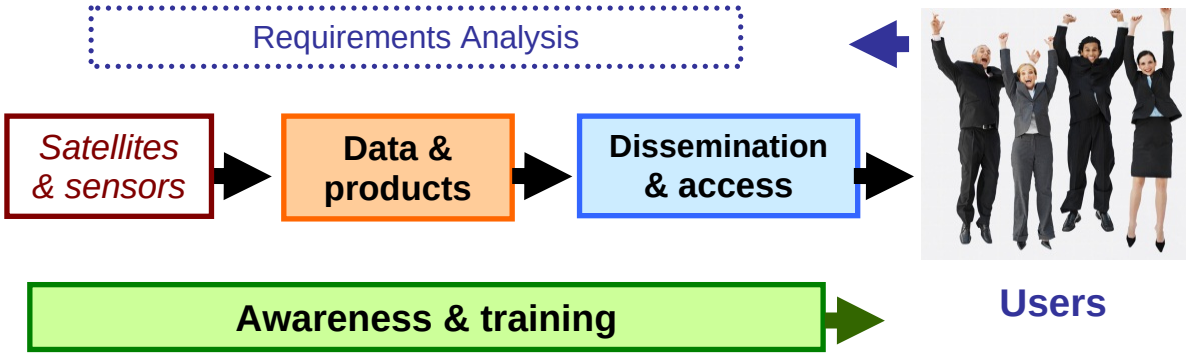

Figure 1: Information value chain in the use of space-based information

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- User uptake, awareness and training
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Background

Background to the present Vision is the "Vision for the GOS 2025" adopted by WMO CBS in 2009, and its associated Implementation Plan. There is a need to accompany the Vision of the GOS by equivalent guidance addressing satellite utilization. Existing mechanisms to support and facilitate the utilization of satellites in the framework of the WMO Space Programme (ET-SUP, VLab, IGDDS, links with international science groups..) will be leveraged.

The Vision for the GOS in 2025 sets a goal to establish several operational satellite constellations, each one covering a specific range of applications. It includes a geostationary satellite constellation with high-resolution multi-spectral Vis/IR imagers, IR hyper-spectral sounders and Lightning imagers; a constellation of operational polar-orbiting sun-synchronous satellites on three orbital planes carrying

IR hyper-spectral sounders, MW sounders and high-resolution multi-spectral Vis/IR imagers; and several other operational constellations of sensors focusing on particular missions such as altimetry, ocean surface winds, radio-occultation, global precipitation, atmospheric chemistry, radiation budget and space weather. Additionally, new instruments should be developed and demonstrated to prepare future advances.

Around a decade ago, the main operating mode of most users was to obtain satellite imagery, in high or low resolution, from direct broadcast. Nowadays, more basic processing tends to be systematically performed by satellite operators and users thus have access to a wide range of elaborated products (level 2 or above). Furthermore, users who generate products can receive their data by various means, either by direct readout or increasingly by retransmission services such as GEONETCAST, or by other ways (e.g., FTP through web portals, GEMPAK, SATAID). Faced with an increasing number of choices of data access, users require guidance.

The number of proposed satellite constellations is very large (at least 10 are listed in the Vision for the GOS in 2025) and the drastic increase in spectral, spatial and time resolution will continue. This will considerably impact end users who should be prepared to use optimally this terrific satellite global coverage. Advances in satellites and sensor technology have changed and will continue to change the utilization paradigm of space-based data.

This document proposes a vision of the utilization of data and generation of products for several classes of applications, from the near real time data use up to the historical satellite dataset for climate studies and the appropriate training and tools.

DEFINITION OF THE USER COMMUNITY

The user community can be categorized along the value chain: in this respect, the main scope of this document is the utilization of satellite data and products by the primary user community receiving the satellite data and processing it for downstream users. The downstream users being e.g. meteorological forecasters or any other application sector relying on satellite data, as for example: environmental disaster management, marine, aviation, agriculture, climate applications.

Consideration could be given also to the requirements of downstream users (service recipients) since these downstream services should be a key driver for the primary users. Figure 2 illustrates different layers of user needs and requirements. A clear terminology should be used to designate the user categories.

Within the primary users, two main groups of meteorological and environmental satellite users can be defined: the direct readout, rather specialized users who are dealing with “raw data” and, on the other hand, the majority of users who are mainly interested in receiving satellite products.

This first category of users, basically relying on Direct Broadcast transform raw data to level 1 (data calibrated and navigated) and assimilate this information in NWP models and/or produce some specialized products like sounding and cloud masking from hyperspectral sensors. The second category of users, the one less specialized, can access satellite products from the Internet or by Digital Video Broadcast (DVB) dissemination services, which allows the reception of large amounts of products using low-cost receiving equipment.

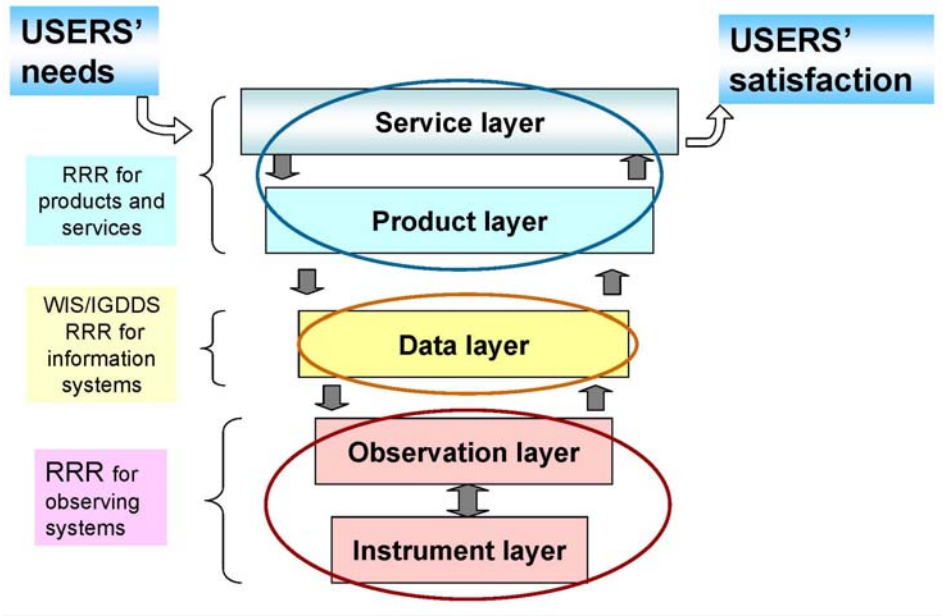

Figure 2: User needs and requirements can be expressed in different layers (observing systems, information systems, products and services).

The ET-SUP-5 (2009) presented a description about these two types of users when discussing about software for satellite users.

The following Earth observation satellite *application areas* are covered in this Vision:

- Numerical weather prediction (including severe weather, tropical cyclones)
- Climate monitoring
- Agricultural meteorology
- Aeronautical meteorology
- Hydrology
- Marine meteorology
- Disaster risk reduction
- Space weather

EXPECTED TRENDS AND ISSUES

On the user side, whether specialized or less specialized one using only products, it is anticipated that in the near future important changes will be needed in hardware, software and people specialization. Several changes can be planned ahead of time, for example for the new generation of satellite systems, direct readout will require using X-band to be able to deliver large amount of data, new data storage and processing capability, new generation of software to combine multiple channels to produce new applications, and specialized visualization systems properly dimensioned to deal with image sizes, number of channels and high time resolution (see GOES-R and MTG description for detailed description of future geostationary satellites) .

1) Reception System and Global Architecture

Key issues

The data rate available from new satellite generations will evolve from less than one Mbps to several tens of Mbps, consequently the system will need more powerful data processing and require new data storage devices. Direct readout users will need to change reception station systems and the

processing chain. Furthermore, in order to exploit the range of expected new products with increased resolution, product users will also need to upgrade their systems to the level necessary to handle this expanded data source. This has also an impact on telecommunications networks and bandwidths, and decisions shall thus be made on which data and products shall be retransmitted on which networks, taking into account the requirements of each regional user community. In each region and for each user community, sufficient preparation to new reception systems shall be foreseen.

Recall of IGDDS priorities endorsed by CBS-XIV:

- To organize the formulation of data requirements and the dialogue between data users and providers; considering the positive outcome of the RAs III/IV Satellite Data Requirements Workshop, the Commission encouraged a similar approach in other Regions where satellite data access is a limiting factor;
- To implement sustainable regional DVB-S dissemination systems offering cost efficient access to satellite data in every region;
- To integrate all relevant data types in such broadcast services, including inter-regionally exchanged data; and
- To support harmonization of future Direct Broadcast systems as well as the implementation of complementary data access and distribution services via the Internet, recognizing the different user needs.

Prospective
Direct readout should continue to be provided to the users at least for the main operational non-geostationary satellite system. This is the most efficient way for satellite users to receive *raw satellite data* with high timeliness constraints. However, some scientific satellite do not have or will not have capability to have direct broadcast, thus raw data from these satellite constellations should be provided through a specific way (internet, ftp, GEMPAK, etc) in near real time under specific request when justified as latency being an important issue. Furthermore some satellite data also require a particularly complex and heavy processing (e.g. radio-occultation, SAR imagery, scatterometer, altimeter) for which the processing is logically centralized in a specialized centre. For the first operation year of a new generation satellite, a virtual image, with the former format and information, will be very important for the users.

Satellite products should be provided in near real time by up-to-date multi-mission dissemination systems such as Geonetcast , if it meets the IGDDS requirements. Data requirements of the different WMO Regions should be frequently updated by the meteorological users, in consultation with end-users. A multi-mission system such as Geonetcast should also be able to provide other ancillary remote sensing data as precipitation field from weather radar, lightning strokes detected by ground systems, etc.

A specific system should deliver data for assimilation in NWP models with the smallest timeliness possible. Global data requirements for NWP are defined by major weather forecast centers running global models in the context, as for example, of the North America-Europe Data Exchange Meetings (NAEDEX) and the Asia-Pacific Satellite Data Exchange and Utilization (APSDEU) meetings.

Global atmosphere models will run cloud resolving models and high resolution data will be necessary. High resolution data need a very short timeliness therefore specific procedures should enable to deliver these large amounts of data in near real time.

2) Pre-processing and Basic Processing Software

Key issues
Direct readout users can be equipped for the new satellite generation by using their X-band antenna (when available), or buying a new one. However, one of the most complex items is the pre-processing software. If pre-processing software is available as freeware, it will facilitate and reduce users'

investments in the new system and allow earlier uptake. Another issue will be software tools to provide data products integration and visualization.

[Refer to ET-SUP and ITWG recommendations].
[Include notion of novel tools for data discovery, exploration and mining]

Prospective
Each new satellite generation, with new devices and sensors, drastically impacts on the routine operation of specialized satellite centers. Therefore, for each new satellite launched the satellite operator will take responsibility to provide open source and freely available pre-processing and basic processing software to accomplish these tasks. For the non specialized users the main software requirement is the ability of integrating products with geographical information. This requirement entails the need of displaying satellite data in well defined landmarks. In particular, users should be able to display this information at the scale that suits them best, according to their type of activity. Users are then interested in performing geographic selections and extractions, temporal animations, combining satellite images with other available information sources of meteorological origin (radar, conventional observations, numerical models outputs, etc) or of other origin (demographic data, mapping, hydrology, roads, etc). To facilitate processing by user, products should have standard formats and protocols to simplify all these development activities.

For data assimilation, guidance should be given to choose in hyper spectral sounding the more appropriate channels for assimilation for a specific synoptic and region, for the main parameters of interest. Also, for this category of data, formats should be standard and specific software for satellite data assimilation should be developed in open source and freeware (see *Fourth WMO Workshop on the Impact of Various Observing Systems on NWP, for a discussion about the impact of instruments in NWP models, 2008)*

Information about satellite calibration, data and products quality will be very important for an expected increase on the number of products and specific use as input in several applications models. GSICS calibration information should be made easily accessible and accompanied with user guidance.

3) Product Generation and Validation

Key issues
There is a need to concentrate financial, technical and human resources to develop, process and validate products that are more and more complex and require increasing expertise and processing capabilities.

The users relying only on products will need sufficiently detailed information on these products to evaluate their fitness for purpose, and use them with confidence. Data/product delivered should contain metadata following the WMO core metadata profile developed by the WIS and internationally agreed formats recognized by WMO (BUFR, netCDF, HDF). New formats as geotiff, well adapted to Geographical Information Systems, should be analyzed by WMO as new alternative format to be included in the format list (see *WMO Guidelines on the use of Metadata for WIS,* 2010).

Prospective
The generation of products will evolve into a sustainable, validated and continuous system. This procedure need to consider the following topics:

- Deliver the algorithm to read and visualize the data.
- Make available a detailed description of the product
- Present regular (e.g., monthly) evaluation of data
- Included free training courses on the use of the products and describing how it was computed.
- Make the products, when possible, compatible with geographical data.
- Maintain online information (e.g., a webpage) on products details that can be referred to in the WMO Product Access Guide, and include metadata for registration in the WIS

- Introduce product-relevant training material into the Virtual Lab resource Library as the Environmental Satellite Resource Center (ESRC)
- Need to join resources to have a critical mass in terms of expertise for development and validation, and in terms of processing. [in the right place?]
- Need to bring products to maturity (See e.g. maturity matrix), properly documented, quality-controlled, over a well defined area of validation.
- Need commitment to sustain the operational production, and consider user feedback
- Regular reviews involving user feedback.

4) User Awareness and Training

Key issues
From the users point of view, particularly the less specialized one or product-only user, new satellite products will be most useful if users have sufficient knowledge and understanding of the satellite, data reception, data processing, the physical basis of the products, the product list and their specific use, the data quality and limitations, and the tools to use and process the data. There is a hierarchy of training ranging from reception to products awareness, the more complex training being given by the satellite algorithm developers.

Prospective
WMO, through the ET-SUP, should consider putting appropriate effort in a product portal to make available information about products, access, guides on how to access specific products, products limitations and qualities, formats, size, and any other ancillary information. ET-SUP has a key role in this respect to evaluate data, products and services and develop user guidance.

The use of advanced systems such as Geonetcast in the context of the WIS, which provide high rate data streams in near real time with a moderate user equipment cost, will continue to increase drastically the number of users. Additionally to the data, specific software for data and products pre-processing and combining visualization with geographical information system will complement the system. Furthermore, the number of specific satellite constellation will also strongly increase. Therefore training will be very important for the full exploitation of these large amounts of different data and software by the user. Virtual training should be prepared for each satellite or constellation to be launched for all different levels of users.

The VLab should help the exchange of trainings and support one-stop shop point for training activities. VLab should forge partnerships in areas of identified need, as appropriate. The concept of Center of Excellence should be expanded to all regions and languages. Some Centers of Excellence also producing products should support regionally the development and use of satellite data.

As new satellites are launched specifics workshops should be prepared dedicated to the users covering topics from the description of satellite, data reception, data pre-processing and products.

5) Data Archive and Access - Assessment

Key issues
Large amount of data will be received need the employ of new storage and processing devices. To support renalysis, for studies or climate applications, long data series are needed.

Prospective
Each satellite or constellation should consider a budget to prepare data archive, with free access. Long term data assessment should be prepared each 5 year of operation. It is important to the user to know if it is possible and how to access historical data or is necessary to store locally the data and products.

This activity should be validated by a group of specialists in radiation processes and satellite

intercalibration.

Satellite agencies should provide information to the users about the basic hardware for the receiving, processing and storing the data system. Preparing users should include guidance on new-generation data management, storage and analysis systems that allow benefiting from data volumes that are orders of magnitude larger than what is available today.

References

CBS-2009- Vision for the GOS 2025

Fourth WMO Workshop on the Impact of Various Observing Systems on NWP, Geneva, Switzerland, 19-21 May 2008 , SUMMARY AND CONCLUSIONS

Geonetcast: http://www.earthobservations.org/geonetcast.shtml

GOES-R Details: http://www.goes-r.gov/mission/mission.html

IGDDS Implementation Plan (v2, 2007)

MTG Details:
http://www.eumetsat.int/Home/Main/Satellites/MeteosatThirdGeneration/index.htm?l=en%20-MTG%20details

Satellite Data Processing and Analysis Software (Initial list): ET-SUP-6 Inf. Doc 1 ,
ET-SUP-5 Doc 12 (General description of software processing tools)

WMO Core Metadata Profile version 1.2. Guidelines on the use of Metadata for WIS, 2010.

WMO Sixteenth World Meteorological Congress, Abridged Final Report with Resolutions (WMO Space Programme on pp 67-69 and 381-384)

WMO Space Programme description

WMO Space Programme Implementation Plan Outline 2008-2011 (for background)

VLab Five-year Strategy

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