WORLD METEOROLOGICAL ORGANIZATION
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COMMISSION FOR BASIC SYSTEMS
OPEN PROGRAMME AREA GROUP ON INTEGRATED OBSERVING SYSTEMS

INTER-PROGRAMME EXPERT TEAM ON SATELLITE UTILIZATION AND PRODUCTS

FIRST SESSION

GENEVA, SWITZERLAND, 16-19 MARCH 2015

IPET-SUP-1/Doc. 6.1
(16.III.2015)
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ITEM: 6.1

Original: ENGLISH

Satellite User Readiness Navigation portal: Status and Development

(Submitted by the Secretariat)

Summary and Purpose of Document

The paper recapitulates the concept and structure of the SATURN portal, and gives an overview of its current status, including the Reference User Readiness Project.

ACTION PROPOSED

The session is invited to:

(a) Comment on the structure and content of the SATURN portal, and provide guidance on potential new elements;

(b) Comment on the Reference User Readiness Project, including details and timelines of deliverables needed by satellite data users.

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Satellite User Readiness Navigation portal: Status and Development

1. Introduction

The new generation of meteorological geostationary satellites being launched by NOAA, ISRO, JMA, CMA, KMA, ROSHYDROMET and EUMETSAT before the end of this decade will provide unprecedented capabilities for the key applications of severe weather monitoring, nowcasting and short range forecasting and for a number of developing application areas, but will also present unprecedented challenges for users worldwide. The main challenge is the order-of-magnitude increase in the amount of data and products to be generated from the advanced imagers and sounders on-board the satellites. In addition, novel data types from geostationary sounders and 16-channel imagers need to be accommodated for by operators and users. These capabilities will be driving the need to develop more advanced techniques for interpretation and assimilation of the data and products generated.

It is a priority of the World Meteorological Organization (WMO) and the Coordination Group for Meteorological Satellites (CGMS) to support the user community in light of these challenges. Satellite data users and WMO members require timely, technical information on the new satellite generation to exploit its potential operational benefits and socio-economic value. The WMO Space Programme, with the support of the CGMS member agencies, is therefore developing the online portal SATURN (SATellite User Readiness Navigator) to provide a single point of access for all information pertinent to the preparation of the global user community for the new generation of satellites.

The initial scope of SATURN has been the new generation of GEO satellites, but it is planned for 2015 to extend the scope of the portal to the core meteorological satellites in low-earth orbit.

The support of CGMS members to achieve this goal is essential, and therefore CGMS has established a task team of agency focal points to provide content for the portal.

Focal points have been nominated from China Meteorological Administration, EUMETSAT, Japan Meteorological Agency, NOAA, Korea Meteorological Administration, India Meteorological Department, and ROSHYDROMET (Russia).

As of March 2015, up-to-date content is being provided for Himawari-8 and GOES-R, and preliminary content is available for Elektro-L, FY-4 and MTG.

This paper presents the concept and structure of the SATURN portal.

To support and guide satellite operators and users in their respective preparation activities, a Reference User Readiness Project has also been developed, and is presented in this paper.

2. Location and Structure of SATURN Portal

The SATURN portal is available under the URL http://www.wmo-sat.info/satellite-user-readiness.

SATURN is essentially a collaborative blog. All content, provided by the individual agencies, is realized as **posts** using the WordPress online developer environment. Each agency focal point is fully responsible for entering and updating posts. The SATURN Administrators (Mikael Rattenborg and Stephan Bojinski, WMO Space Programme) ensure the overall consistency and re-order posts as necessary, as well as include links to other information of relevance to the user preparations, in particular to training material provided by other institutions, and to user community information fora.

The overall logic is that posts related to the satellites are ordered according to the planned launch dates, with Himawari-8 first and MTG last.

To offer different entry points for the user of SATURN, a hierarchical category structure has been developed. The categories are visible in the main menu structure where the 1st level categories, ("Satellite", "FAQ", "Data Access and Use", "Planning for Readiness") make up the main menu, with subcategories appearing in dropdown menus.

Each post is attached to one or several "categories" or "sub-categories" depending on where it should appear in the navigation. The four categories and associated subcategories are:

2.1 Satellites

With subcategories:
1. Himawari-8
2. ELEKTRO-L N2
3. INSAT-3DR
4. FY-4A
5. GOES-R
6. GEO-KOMPSAT-2A
7. MTG

2.2 Data Access and Use

Here the subcategories are:
1. Data, Products and Applications
2. Data Formats and Volumes
3. Data Access Mechanisms
4. Software Tools and Test Data
5. User Notification and Feedback
6. Training and Resources

2.3 Frequently Asked Questions

Here the subcategories are the typical questions a user, be it an individual or a national meteorological or hydrological service (NMHS), would ask as part of the preparation for the new satellites:

1. Can I use my old receiving equipment?
2. How can I get access to the data and products?
3. How can I get hold of synthetic/proxy/heritage data?
4. How can I use the data and products for my own application?
5. What do I need to change and how much will it cost me?
6. When will the different data and products become available after launch?
7. Where can I find a community that shares my interests?
8. Where can I find technical and scientific training material?
9. Which data and products will be available from the operators?
10. Which formats will the data and products be in?
11. Where do I find detailed instrument spectral response functions?
12. What radiative transfer models are used or recommended with the satellite instruments
13. Where will I find instrument monitoring performance post-launch, during cal/val and long term?
14. Are there SI traceable calibration standards for this/these instruments?

2.4 Planning for Readiness

Here the satellite operators provide detail on their activities to support user readiness. This includes: plans for the provision of test data and tools, product specifications and format descriptions, data access mechanism specifications, instrument specification and performance data, training resources, operational scenarios, operational services specifications, etc. This category also includes a generic reference user readiness project.

3. Reference User Readiness Project

The WMO guidelines on user preparation for the new generation of meteorological satellites adopted at CBS-XV in 2012 urges each of the NMHSs and other operational user organizations to:

“Establish a user readiness project focused on the introduction of new satellite data streams into operations (to be initiated ~5 years prior to launch)”

One of the main constraints for the planning of a user readiness project is the timely availability of information, specifications, and data and tools used in satellite system development. Therefore, to establish a user readiness project, it is important to consider in detail the lifecycle of satellite system development and its relation to the user readiness planning.

It is therefore crucial, that the satellite development entities and operators provide detailed and up-to-date plans for their activities conducted in support of user readiness projects.

Even though user readiness is explicitly considered for ongoing satellite system development projects such as for Himawari-8/9 or GOES-R, satellite operators do not generally provide a up-to-date planning schedules of deliverables to the user community.

Therefore the WMO Space Programme has analyzed how the typical satellite system development cycle relates to typical user readiness projects, and the outcome of this analysis is a summary of best practices and a generic schedule, indicating at what time (relative to planned launch) what information should be available in order to both satisfy the user preparation schedule and respect the constraints of satellite system development.

3.1 User activities

3.1.1 Budgeting and planning

Budgeting and planning is of paramount importance and need to start early. A new generation satellite system can be in some cases the driver of significant infrastructure upgrades; performance requirements in terms of data acquisition, storage, network, etc. should thus be known many years in advance in order to incorporate the necessary upgrades in the long-term evolution and investment plans. Realistic schedule margins and other provisions should be used to avoid planning difficulties for example due to launch delays

A main objective for a user organization like an NMHS, is to protect the investment made into existing operational programmes, and to understand early where additional investments are necessary or unavoidable in order to achieve readiness for the new satellite system. Therefore, early information about investment drivers is crucial for budgeting and planning purposes.

3.1.2 R&D

In this context, R&D refers to the phase of activities that prepare for routine operations of new generation satellites from the user perspective. This typically includes development of NWP data assimilation methods using the new generation satellite data where needed, or development of new or specially tailored products for specific application areas required by the individual user. The planning of such activities varies widely according to the needs and capabilities of the user organization (e.g., NMHS), in particular for the NWP centres.

3.1.3 Data handling development and testing

This activity includes design and procurement of new satellite reception systems, as well as upgrades to terrestrial network access (Internet and RMDCN), needed for handling increased data rates. The activity would also encompass upgrades to observational databases, short- and long-term archives, as well as to internal networks and general IT capacity.

3.1.4 Data processing development and testing

All aspects of the processing of satellite observations need to be adapted and potentially upgraded to accommodate data from the new satellite. This may include:

- Local processing of direct broadcast data into L0 and L1 products
- Transformation of received data into intermediate local formats for observations databases and archiving
- NWP assimilation,
- Local generation of higher-level products for specific application areas
- Visualization tools, both for analysis by experts as well as for general forecasting

In particular, the adaptation of NWP assimilation to the new satellite systems requires a long lead-time and has very specific requirements regarding availability of instrument and product data. A best case timeline for deliverables to be provided from the satellite development programme to support NWP preparations is given here (with thanks to the ECMWF Satellite Section):

- L-36 months: Supply basic description of instrument(s)
- L-24 months: Supply full description of instrument(s), including planned SRFs, noise, FOV size, dataset names, etc
- L-18 months: Supply full pre-flight instrument characterisation information (including SRFs, noise, etc), L1B data format details, Sat Id, navigation info, data dissemination plans
- L-12 months: Provide information on radiative transfer models (e.g. RTTOV) that can support instrument(s)
- L-12 months: Provide simulated level 1 data in data format to be used for NRT distribution
- L-6 months : Provide Direct Broadcast software package (if DB available)
- L-6 months : Provide L2 data format (if L2 available)
- L-6 months : Test operational dissemination route with simulated data

The exact timings of these deliverables depend to some extent on exactly how "new" the instrument actually is. If it is just a new one in an existing series, lead times can be shortened considerably and some steps (e.g. simulated data) can be dropped completely. For totally new instruments (e.g. MTG-IRS) however, a first-guess-ISRF would be useful even earlier than L-24 months, and simulated data would also valuable.

3.1.5 Training

Different training subjects and different target groups for training exist and it is important to identify the different categories of needed training as they have different time scales and require different levels of information about the new satellite system.

Identified training subjects are:

- Equipment operation and maintenance
- Interpretation of L1 data from satellite payload instruments including:
    - Imagery interpretation
    - Passive sounder data usage
    - Active instrument usage
- Use of software tools (for processing, analysis, and assimilation)
- Derived L2 product utilization and interpretation
- The physical basis of remote sensing, in particular as it applies to new instruments

Target groups for training are:

- Trainers (using the “train the trainers” approach)
- User readiness project managers
- Operational forecasters
- User communities in NWP and other application areas
- Organizational managers
- Technical support personnel
- R&D personnel

The approach for organizing training depends very much on the needs and capabilities of the user organization (NMHS) and on the organizational relationship between satellite operators and users. With the advancement of e-learning technology, emphasis is clearly shifting from long-term planned classroom training towards “just-in-time-training” based on webinars, self-study online training etc.

High-level guidance for training in satellite meteorology is available in the Strategy for the CGMS Virtual Laboratory for Education and Training in Satellite Meteorology (http://www.wmo-sat.info/vlab/wp-content/uploads/2012/02/SAT-ST-09_VL-5year-strategy_V2.pdf, 2009-2014 version; to be updated in 2015)

3.1.6 Capacity building

Capacity building is vital for ensuring that all WMO members can maximize their capability to exploit the value of the new generation of satellite data. Such activities can take the form of bilateral NMHS partnerships, regional collaborative mechanisms like the RA I Dissemination Expert Group and the EUMETSAT User Forum in Africa, the RA II WIGOS project on satellite utilization, or major projects providing technical and scientific infrastructure and training for less developed WMO members (e.g. AMESD and MESA).

3.1.7 Contributions to Calibration/Validation

Participation of NWP centres in instrument Cal/Val activities have become standard practice both for LEO and GEO satellites. Monitoring of first-guess minus observation (FG-OBS) departures for L1 products are an important contribution to the Cal/Val activities of satellite operators.

3.2 Satellite system development phases

The life cycle of space projects is typically divided into 7 phases, as follows:

- Phase 0 – Mission analysis/needs identification
- Phase A – Feasibility
- Phase B – Preliminary Definition
- Phase C – Detailed Definition
- Phase D – Qualification and Production
- Phase E – Utilization
- Phase F – Disposal

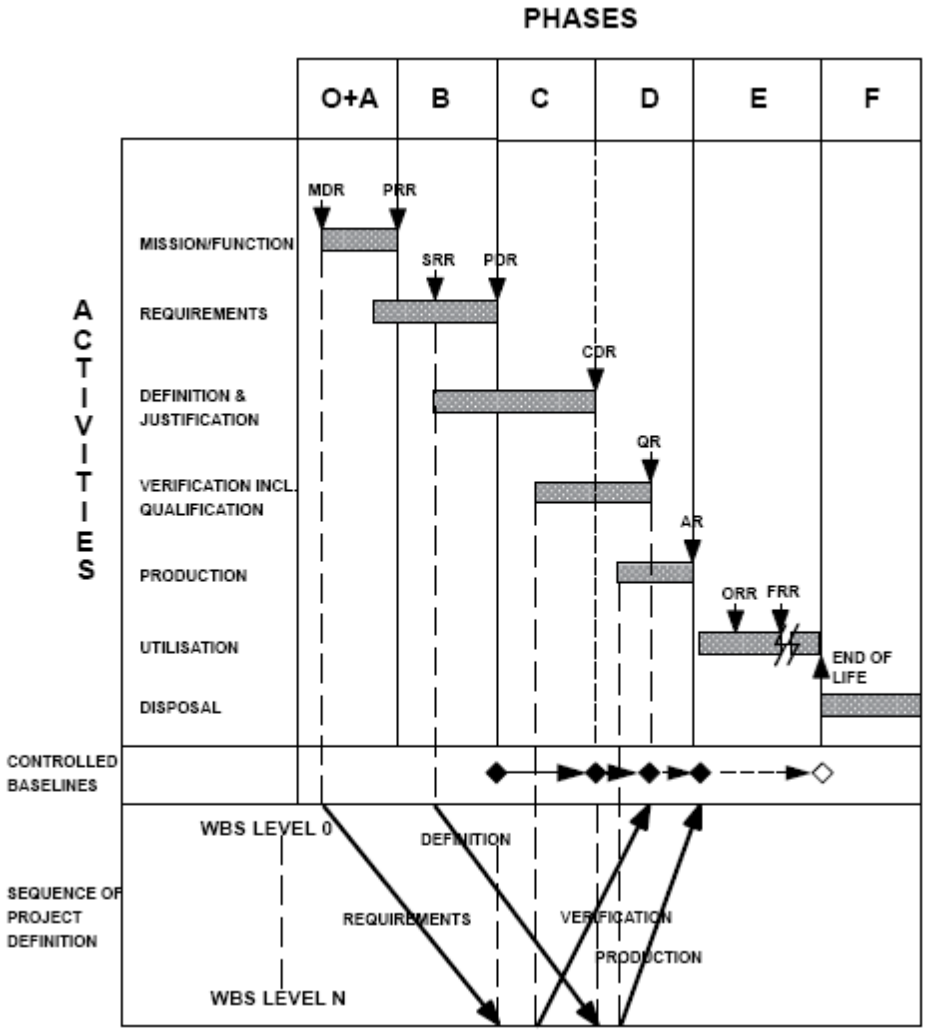

Figure 1: Reference satellite system development lifecycle according to European Cooperation for Space Standardization (ECSS)

Phase C (detailed definition) is concluded with the System Critical Design Review (CDR), at which point the definition of the system (satellite and ground segment) will be complete down to the lowest level, and after which full production (Phase D) of the system will start. If development follows a nominal schedule, the System CDR will take place 3 years before launch. Phase E (utilization) starts with the shipment of the satellite to the launch site and the start of launch preparations, and is subdivided into phase E1 (launch and commissioning), typically lasting until 6-12 months after launch, and phase E2 (routine operations).

The most significant consequence of this lifecycle with respect to the user community is that

the system specification and other information made available to the user community before the System CDR (i.e., at the end of Phase C) will be based on requirements, whereas deliverables based on the real characteristics of the system will only become available after this time, during phase D and E1.

This lifecycle reflects actual experience from MSG and COMS, and also the status and planning for GOES-R and MTG. Variations do exist for specific programmes; for example the planning for Himawari-8 development was somewhat compressed compared to this: the System Critical Design Review was completed in January 2012, only 30 months before the planned launch in summer 2014 (the satellite was successfully launched on 7 October 2014).

3.3 Deliverables to user activities

3.3.1 Instrument characterization

Details of instrument characterization and performance are of general interest to the user community, but are particularly critical for the adaptation of NWP assimilation of L1 data. Initially these data are based on instrument specifications, but following on-ground instrument testing, actual instrument characterization data will become available from the satellite manufacturer based on this testing. The provision of these data from industry to the satellite operator is generally regulated in the overall satellite contract, and subject to a significant set of contractual constraints.

It is planned in cooperation with relevant expert teams to develop a standard checklist for pre-launch instrument characterization.

3.3.2 Product specifications

This includes scientific specifications of the product algorithms, detailed specification of formats for dissemination as well as on-demand requests, information on timeliness and expected data volumes, all for both L1 and L2 products.

There is clearly a need for more standardized approach to description of both L1 and L2 products, possibly through the development of standard templates for the product description.

3.3.3 Data access mechanism specifications

This includes specifications of mechanisms for direct-readout, direct dissemination and DVB-based dissemination. These specifications are required for procurement of all user reception systems.

Also required are specifications of offline data access mechanisms, including archive retrieval and other on-demand means.

Where user registration is required for access to products and services, detailed description of the user registration process is required before launch, so that the registration process can be exercised by the users already during the commissioning phase.

3.3.4 Software tools and test data

L1 pre-processing software is needed for the procurement of the user data processing functions, but realistically is only available from an operator after Ground Segment acceptance. Any contracts for procurement of data processing systems need to take this need into account.

Different categories of test data exists, with different life cycles. The categorization used in the SATURN portal is the following:

- Synthetic data: No scientific value, but realistic sizes and formats. Used for user dataflow testing
- Proxy data: Data simulated by forward Radiative Transfer Model (RTM) calculations. Proxy data are used to test processing and visualisation tools. These data are produced based on NWP model output, they generally do not contain realistic spatial structure and temporal variability.
- Heritage data: Actual data sets from relevant precursor instruments, e.g., 2.5 min data from Meteosat-10 for MTG-FCI, 1-min super rapid scanning data from GOES for GOES-R ABI, or IASI/AIRS data for FY-4A GIIRS and MTG-IRS. Heritage data are used in early training on capabilities and application areas. It is also possible to use heritage data to construct test data similar to proxy data by adding RTM simulated data for channels to the ones present in heritage mission or by using interpolation in time and space.
- Pre-operational data: Real satellite data generated as part of the commissioning activities, but before full validation has been completed.

The operators should provide all of these categories of test data, as well as software tools provided for the use of test data, both during pre-launch development and during post-launch commissioning activities.

3.3.5 Operations plans and schedules

For ensuring user readiness, it is of high importance that both long-term operations plans, as well as routine operations schedules are made available before the start of routine operations. This includes the following elements:

- Fly-out plan for overall satellite programme, including planning for launches, orbital positions and end-of-life dates, including information about overlap with existing operational satellites
- Routine operations schedule, including areas of coverage for flexible scanning operational scenarios and information on the process for scenario switching, e.g., activation of Super Rapid Scanning operations for severe storms and tropical cyclone tracking.
- If appropriate, conditions for user input to the operations schedule (e.g. requests for special mode operations)
- Planning for routine spacecraft maintenance activities, like orbital manoeuvres, seasonal spacecraft re-orientation (yaw-flip), instrument decontamination etc.
- Schedules for activation of LEO direct broadcast where applicable
- Schedules for routine dissemination for both direct broadcast and re-broadcast via telecommunications satellites.

Details on recommended due-by-dates are provided in the timeline below.

3.3.6 User Notification and Feedback

It is essential that the satellite operator establish 2-way communications channels to the user community: for providing general and specific information, and to allow users to make enquiries and provide other feedback during the preparations phase. Such channels are also necessary to provide routine user support starting from the commissioning phase.

Such communication should include Regional satellite user coordination mechanisms (such as the Coordination Group on Satellite Data Requirements for Region III and IV; RAIDEG),

regional user conferences (such as the Asia-Oceania Meteorological Satellite Users Conference) and training events (such as the GOES-R Event Week), as well provide support for enquiries and feedback from individual users.

3.3.7 Training resources

For new satellite systems, the provision of training material from satellite operators is crucial. Online training resources are of increasing importance, and give the possibility of dynamic adaptation when new information about the satellite and its applications becomes available. It is also essential to capitalize on the contributions of the user community and promote training resources that are made available by user groups.

3.3.8 Other deliverables

For many applications, it is important to have the set of fundamental constants that have been used to derive satellite data and products, and satellite operators should make this available to users. It is planned to propose a common standard to be used by CGMS operators, e.g., the list published by the US National Institute of Standards and Technology (NIST).

3.4 Timeline for the Reference User Readiness Project

The table below shows the overall timeline of user preparedness activities, and the planning for the different deliverables from the satellite system development needed to support these activities.

Each user deliverable in the reference project has an associated sub-category in SATURN, so that the portal will provide up-to-date links to all deliverables when these become available from the satellite system development.

Time relative to Launch Date (“L”)	Satellite System development Activities and Milestones	User readiness Project Activities and Milestones	Needed deliverables from operators
L-5y (years) -> L-4y	Ground Segment Development Phase C	Initiation of user (e.g., NMHS) readiness project. Initiation of cooperative projects addressing needs of less developed WMO members.	Overall specifications of user segment, including high-level definition of migration path from existing user segment. Preliminary schedule for deliverables to users
L-4y -> L-3y	System Critical Design Review	Identification of drivers for investment and running cost. Planning and allocation of human resources and budgets for investments and running costs. Establishment of prioritized data requirements, as clear priorities for current and future products allow the best preparations to be made for establishing data access and delivery capabilities. Initial training on capabilities for trainers and decision makers.	General description of NRT dissemination mechanisms. Detailed specifications of L2 and L1 products to be available at start of operations (Day-1 products). Heritage test data. Plans for evolution of products after start of operations (Day-2 products).
L-3y -> L-2y	System Production On-ground characterization of instruments	Design of new reception system. Design of communications network changes, including GTS/RMDCN capacity. Design of new data handling and processing functions. Training on specific application areas, based on proxy data.	Specifications of instruments performance. Proxy test data Detailed specifications of NRT dissemination mechanisms. Detailed specifications of Direct Broadcast mechanisms, including frequency and signal characteristics. General description of offline data access. Data/product volume estimates. Data/product format definitions. Data access conditions (e.g. licensing, key units, etc).

Time relative to Launch Date ("L")	Satellite System development Activities and Milestones	User readiness Project Activities and Milestones	Needed deliverables from operators
			L1 pre-processing software. Establish and use 2-way communication channels for user enquiries
L-2y -> L-1y	Ground System acceptance	Procurement, installation and acceptance testing of systems. Software design for data processing, including NWP ingest.	Synthetic test data Continuous periods test dissemination of synthetic test data. Long-term operations plan. Planning for data exchange to serve global community.
L-1y -> L-6m	Flight readiness of satellite	End-user training (forecasters)	Start of regular updating of plans for launch and commissioning.
L-6m -> L	Operational System Validation and Launch preparations	Data processing software testing (using proxy data). Technical training on reception systems and other system elements. Data acquisition system testing (using synthetic data).	Proxy data based on on-ground instrument characterization. User documentation for dissemination mechanisms and delivered software tools. Routine operations schedules.
L->L+6m	Satellite In-orbit verification Commissioning of L1 products	Full system and software testing (using pre-operational data). Support to operators CAL/VAL activities, in particular through NWP assimilation.	Early dissemination of un-validated L1 data. Early switch-on of Direct Broadcast Pre-operational L1 data dissemination. In flight characterization of instrument performance. Start of routine User Support
L+6m->L+2y	Commissioning of L2 products	Scientific data exploitation (iterative based on increased understanding of real data).	Operational L1 data dissemination, from both old and new satellites (as long as possible, but minimum until

Time relative to Launch Date (“L”)	Satellite System development Activities and Milestones	User readiness Project Activities and Milestones	Needed deliverables from operators
		Post-launch training based on real data. Declaration of user operational readiness	L+1y).