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Best Practices for Achieving
User Readiness for New Meteorological Satellites

Reference User Readiness Project

HLPP reference: 5.3.11

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)"

Against this background, Seventeenth World Meteorological Congress 2015, through Resolution 37 (Cg-17), recommended "to all concerned Members to set up user preparation projects in advance of the launches of new satellite systems, in accordance with the CBS Guidelines for ensuring user readiness for new generation satellites."

It is 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. The WMO Space Programme has, supported by a number of experts, analysed how the typical cycle of satellite system development relates to typical User Readiness Projects, and the outcome of this analysis is a summary of best practices and a generic project schedule. The generic schedule indicates 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. Section 5 of the document provides detail on the deliverables that are needed from satellite development programmes to support user readiness projects.

The document presents, in an integrated manner, Best Practices for User Readiness Projects performed by user organisations (e.g. NHMSs) as well as for satellite development programmes in support to user readiness.

Action/Recommendation proposed:

- WG IV to consider the content of the document and recommend that CGMS plenary adopts the document, in as far as it applies to satellite operators, as CGMS Best Practice

W O R L D M E T E O R O L O G I C A L O R G A N I Z A T I O N

Best Practices for Achieving User Readiness for New Meteorological Satellites

Reference User Readiness Project

WMO Space Programme

24 April 2016

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Inclusion of final pre-launch checklist from GSICS and CEOS WGCV	5.1	24/04/16	

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Best Practices for Achieving User Readiness for New Meteorological Satellites

Reference User Readiness Project

1. BACKGROUND

Nearly all geostationary meteorological satellite systems in the world are replaced by a new generation in the 2015-2020 timeframe, by Japan, China, the United States of America, the Republic of Korea, the Russian Federation, and EUMETSAT. The new generation satellites will carry advanced imagers providing at least 16 spectral channels (14 channels only for the FY-4 series, but supplemented by an interferometric sounder) and flexible rapid-scan capabilities, with additional innovative payloads, such as lightning mappers, for some of the programmes (see Table 1). Other new-generation systems will be deployed in polar orbit and other orbit types in the coming decade.

Table 1: Planning status of new-generation geostationary meteorological satellite systems (Status: March 2016)

Satellite	Operator	Launch date	Longitude	Imager	Number of spectral channels	Spatial resolution	Temporal resolution (full disk)	On-board Sounder / Lightning Mapper
Himawari-8*	JMA	7 Dec 2014	140E	AHI	16	0.5-2km	10min	- / -
Electro-L N2	ROS-HYDROMET	11 Dec 2015	78E	MSU-GS	10	1-4km	15min	- / -
INSAT-3DR	ISRO	2016	74E	IMAGER	6	1-8km	30min	S / -
GOES-R	NOAA	2016	137W	ABI	16	0.5-2km	15min	- / L
Himawari-9	JMA	2016	140E	AHI	16	0.5-2km	10min	- / -
FY-4A	CMA	2017	86.5E	AGRI	14	1-4km	15min	S / L
Geo-KOMPSAT-2A	KMA	2017	128.2E	AMI	16	0.5-2km	10min	- / -
GOES-S	NOAA	2017	75W	ABI	16	0.5-2km	15min	- / L
MTG-I/S	EUMETSAT	2019-21	9.5E	FCI	16	0.5-2km	10min	S / L
FY-4B	CMA	2019	105E	AGRI	14	0.5-4km	15min	S / L

*Himawari-8 is operational since 7 July 2015**; Source:** OSCAR/Space

The new generation of satellites will bring significant enhancements to satellite-based products and services delivered by WMO Members, provided that users can effectively reap their benefits: ingesting the new data types in operational schemes, with overall data volumes one magnitude higher than today, has major impact on user infrastructure, systems, applications and services, and require coordinated action at the scientific, technical, financial, organizational and educational levels. Timely and careful preparation by satellite data users is essential to avoid any disruption of operations upon transition to these new systems, and to ensure that Members take advantage of the new capabilities effectively, and as early as possible.

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)"

Against this background, Seventeenth World Meteorological Congress 2015, through Resolution 37 (Cg-17), recommended "to all concerned Members to set up user preparation projects in advance of the launches of new satellite systems, in accordance with the CBS Guidelines for ensuring user readiness for new generation satellites."

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 activities are explicit elements of ongoing satellite system development programmes such as for Himawari-8/9 or GOES-R, satellite operators often do not systematically provide up-to-date planning schedules of deliverables to the user community.

For this reason, World Meteorological Congress in 2015 also urged "the satellite operators to provide regular and timely updates on their new systems through appropriate means and in particular through inputs to SATURN and OSCAR."

Therefore, the WMO Space Programme has analysed how the typical cycle of satellite system development relates to typical User Readiness Projects, and the outcome of this analysis is a summary of best practices and a generic project schedule. The generic schedule indicates 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.

2. APPLICABILITY

The current document presents, in an integrated manner, Best Practices for User Readiness Projects performed by user organisations (e.g. NHMSs) as well as for satellite development programmes in support to user readiness. The document contains definitions of, and a timeline for, deliverables that should be made available by the satellite development programmes to user readiness projects.

The Best Practices documented here therefore apply to both user organisations (section 3) and satellite operators (section 5).

The primary audiences for this document are members of CGMS and WMO, but the broader user community can equally benefit from the information contained.

3. ACTIVITIES BY USERS TO ACHIEVE READINESS

These activities should be performed by user organisations (e.g. NHMSs) to achieve readiness for new-generation satellites.

3.1 Establishment of a User Readiness Project

It is crucial that planning starts early. This document assumes that users need to prepare for an entirely new generation of satellites, where the User Readiness Project needs to defined 5 years prior to launch. In particular, it is crucial to:

- Clearly define project outcomes and deliverables
- Establish clear responsibilities and accountabilities
- Ensure adequate budget is available for all activities
- Establish a clear go-live planning for upgraded infrastructure and for new services

The User Readiness Project needs to address

- New capabilities as well as improvements of existing capabilities
- Continuity of operational service provision, including critical path analysis for transition
- Maximum benefits from existing assets, protection of investment
- Maximising value of service at all times during transition

and must include a detailed assessment of opportunities and risks.

During the execution of the project, special consideration must be given to:

- Need for a dedicated project and project manager (Overall accountability is important)
- Maintain contact with satellite operator for up-to-date information
- Regular communication to key managers and project stakeholders (maintain momentum and counter misinformation).
- Monitor key project milestones and escalate when necessary
- Ensure management support and buy in is available when needed
- Manage expectations regarding availability of new products.

3.2 Budgeting and planning

Budgeting and planning is of paramount importance and needs 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.

3.3 Research & Development

In this context, R&D refers to the phase of activities that prepare the application of new generation satellite data 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, for instance by centres such as the EUMETSAT Satellite Application Facilities. These activities typically include analysis of the effects of instrument spectral response functions (SRF), field of view (FOV), and the radiative transfer models used to simulate instruments. The planning of such activities depends, to a large extent, on the degree of novelty of the instrument. If it is an upgraded version of an existing series, the 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 SRF can be useful as early as than two years before launch date (L-24 months) and for these, simulated data would also be very useful.

3.4 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 for visualization, monitoring and processing.

It is crucial that the procurement of data handling systems starts early to enable complete testing of all technical and scientific aspects of the processing chain.

3.5 Data processing development and testing

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

- Local processing chain of direct broadcast data into L0 and L1 products
- Data conversion into intermediate local formats for observations databases and archiving
- Data monitoring and assimilation into NWP models,
- Processing chain for local generation of higher-level products for specific applications
- Integration into the operational user environment, including for instance integrated visualization applications (with satellite, radar, surface and altitude observations and model outputs) for forecasters.

For instance, the adaptation of NWP assimilation to the new satellite systems require a long lead time and has specific requirements regarding availability of instrument and product data.

The planning of such activities varies widely according to the needs and capabilities of the user organization (e.g., NMHS).

3.6 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. Satellite skills and knowledge for operational forecasters endorsed by WMO should serve as general guidance for framing training activities.

Identified training subjects are:

- Similarities and differences with respect to existing satellites
- Equipment operation and maintenance
- Interpretation of L1 data from satellite payload instruments including:
    - o Imagery interpretation
    - o Passive sounder data usage
    - o Active instrument usage
- Use of software tools (for processing, analysis, and assimilation)
- Derived L2 product utilization and interpretation
- Understanding of data formats and dissemination
- 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 (e.g., 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.

The increasing importance of continuing training activities after launch must be emphasized. Training needs to cover critical real weather situations for all seasons and it must be based on the real characteristics of the satellite systems. Emphasis should be given to training formats that can be integrated into ongoing operations, i.e. short training modules for “as it occurs” training of operational forecasters on or between shifts. This approach is for example reflected in the NOAA GOES-R training planning (Figure below), extending baseline training activities until 1-2 years after launch.

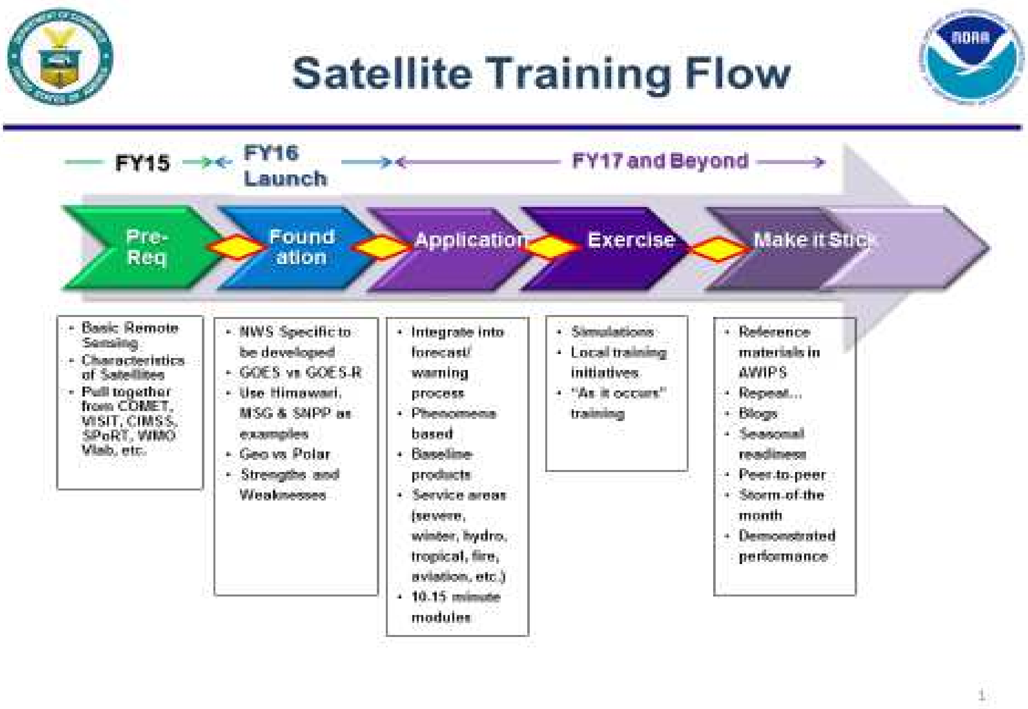

Figure 1: GOES-R Training Plan

The new generation GEO satellites have strong similarities in instrumentation (e.g., similar spectral, temporal, and spatial resolution of imagers; lightning mappers), and therefore, there are substantial potential benefits to users and to satellite operators in developing common training material and in fostering common development of applications.

The training programme run by the Australian Bureau of Meteorology VLab training centre to prepare users nationally and in WMO Region V (South West Pacific) for the effective use of new-generation Himawari-8 data is a good example for assisting user readiness: http://www.virtuallab.bom.gov.au/training/hw-8-training

In collaboration with the VLab and the COMET/MetEd programme, SATURN now links to online training material on Himawari-8 and GOES-R, in English and Spanish (where available). For example, the COMET/MetEd module “Advanced Himawari Imager (AHI): What’s Different from GOES-R ABI” (http://www.meted.ucar.edu/satmet/himawari_ahi/) is very effective in comparing these two imagers, and this module (https://www.meted.ucar.edu/goes_r/abi_es/) explains the GOES-R ABI in Spanish. Translation of more training material is planned and a high priority for WMO and the VLab.

The VLab strategy 2015-2019 places high emphasis on building capacity among WMO Members for understanding and exploiting data from the new generation satellites. The VLab will play a key role over the coming years in addressing the training needs of meteorologists with regard to the new generation of satellites, and strong support from CGMS members will be required.

3.7 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).

Capacity building should also engage the academic community. It is important to ensure that researchers and students become engaged in scientific activities related to the new instruments, in particular since this will benefit the operational exploitation in the longer term.

3.8 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.

4. SATELLITE SYSTEM DEVELOPMENT PHASES

In executing a satellite system development programme, the following activities are typically performed by satellite operators, in cooperation with R&D satellite agencies and industry partners.

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

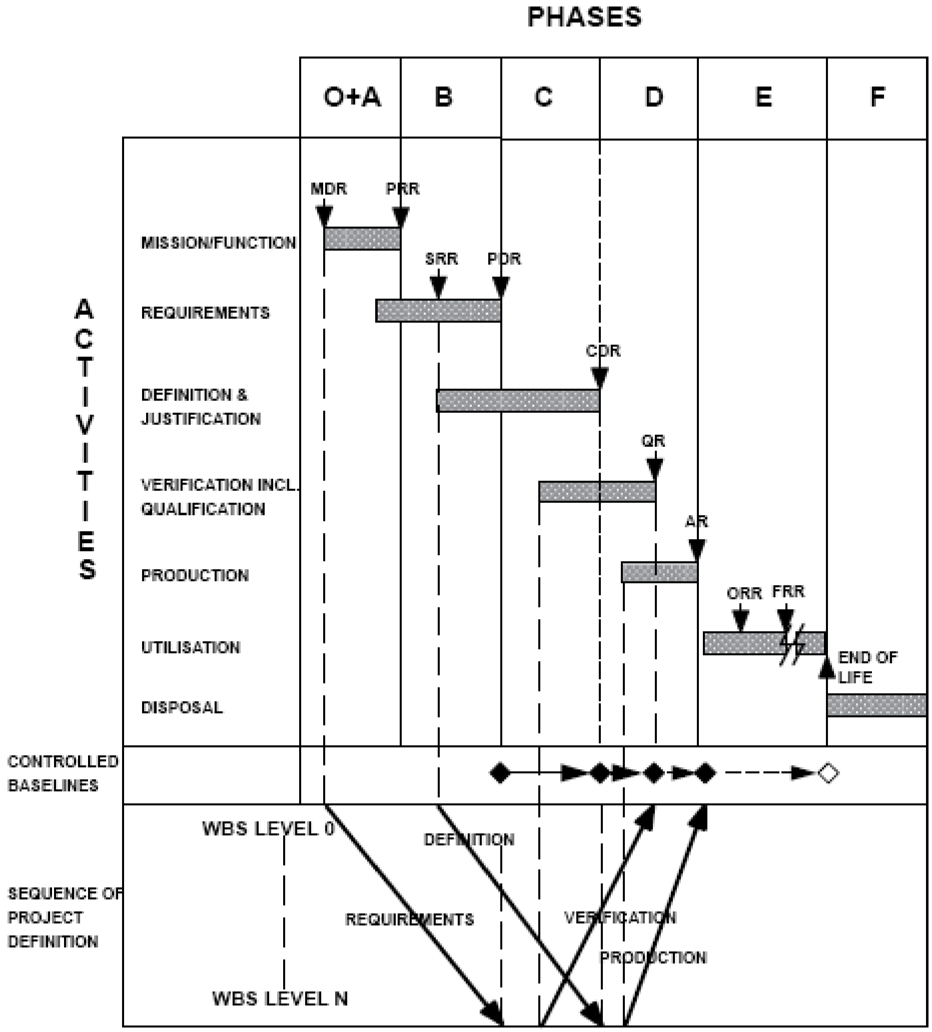

Figure 2: Reference satellite system development lifecycle according to European Cooperation for Space Standardization (ECSS)

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: 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).

5. DELIVERABLES FROM SATELLITE DEVELOPMENT PROGRAMMES TO USER READINESS PROJECTS

This part of the document contains high-level specifications for the different items produced by the Satellite Development Programmes that should be delivered to the User Readiness Projects. The timeline of the deliverables can be found in section 6.

5.1 Instrument pre-launch calibration and characterization

Satellite remote sensing instrument pre-launch calibration and characterization data are critical for the production of calibrated and geolocated Level 1 data and their processing by NWP and climate applications. Satellite instrument pre-launch testing must strive to reproduce, as closely as possible, instrument operation in the predicted on-orbit environment. This is also known as “testing as you fly.”

The latest generations of satellite instruments employ increasingly complex focal planes, often with two dimensional detector arrays and innovative read-out schemes producing large amounts of data. While acknowledging this increasing complexity, as well as the contractual constraints vis-a-vis the involved industrial parties, making the calibration and characterization data produced by this testing available to the user community should allow the instrument behaviour to be fully understood by the time of launch and facilitate proper and efficient use by the remote sensing community. , This will also help meeting as early as possible the on-orbit performance requirements.

The following data should be provided, as applicable, 2-3 years before launch or 6 months before launch, and updated during commissioning (these requirements were established jointly by experts from Global Space-based Inter-calibration System (GSICS) and the CEOS Working Group on Calibration and Validation).

1) To be made available to users 2-3 years before launch to aid user preparation:

- Channel naming, numbering convention and channel science application(s)
- Spectral Response Function (SRF) (relative Radiometric Spectral Responsivity (RSR))
    - Channel central frequencies/wavelengths and bandwidths (full width half max power)
- Pixel sampling distance/time intervals
- System level instrument noise (i.e. NEdL, NEdT), including calibration noise, as a function of instrument parameters (temperatures and voltages) – and reference scenes where they are valid
- Radiometric calibration and characterization:
    - Polarisation sensitivity and response versus scan angle
    - Dynamic range, linearity, quantisation

- Expected mission and instrument lifetimes

2) To be provided 6 months before launch, and updated during commissioning:

- Spectral Response Function (SRF) (relative Radiometric Spectral Responsivity (RSR))
    - Responsivity versus wavelength as a function of channel (i.e. average) and detector
- Along-scan and in-track Field of View (FOV)-pixel size or full PSF/MTF/antenna pattern
- Field of Regard/swath coverage, repeat cycle /orbit configuration
- Radiometric calibration and characterization:
    - Full calibration error budget
    - Response versus scan angle
- Instrument pointing, geometric accuracy and band-to-band calibration/registration (i.e. geometric performance)
- Key parameters of on-board calibrators (i.e. blackbody emissivity and temperature uniformity, solar diffuser spectral Bidirectional Reflectance or Transmittance Distribution Function (BRDF or BTDF) and uniformity).
- Target and realized measurement uncertainties for the above data

3) General recommendations:

- All the above should indicate the level of maturity of the determination of instrument testing parameters. This is accomplished by identifying if the data were determined using analysis/modelling, demonstration, inspection, or testing at the part, subassembly, subsystem, system or observatory (i.e. spacecraft plus instruments) level.
- Pre-launch test data should be provided for all potential instrument on-orbit operational configurations.
- All information should be retained indefinitely.

Mechanisms must be established for providing to users all information about events that affect the inflight instrument performance. To address this, the GSICS project coordinates the implementation of operational instrument event logs.

5.2 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 a need for more standardized approach to description of both L1 and L2 products, potentially through the development of standard templates for the product description.

It should be noted that for the online Product Access Guide, see: http://www.wmo.int/pages/prog/sat/documents/SAT-GEN_PAG-concept-v1.0-final.pdf#10, WMO has introduced a standard classification of Level-2 products.

5.3 Data access mechanism specifications

This in particular includes specifications of mechanisms for Direct Broadcast and for DVB-based dissemination. These specifications are required for the procurement of user reception systems.

Systems requirements for Direct Broadcast reception systems, including both antennas, front-end components and computer systems for acquisition and L1 processing need to be available to users in time for starting procurements activities, typically 3 years before launch. The processing systems requirements are becoming increasingly demanding with the complex processing of Direct Broadcast data for the new generation of satellites; the impact on users' systems is significant.

Also required are specifications of other near-real time dissemination mechanisms employing terrestrial communication, and 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.

5.4 Software tools and test data

L1 pre-processing software is required for the development of the user data processing functions, but in many cases 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, to allow early deliveries.

Software tools can also be developed by experts in the user community, but for a new generation of satellites, these software tools will always depend on L1 processing kernels developed as part of the satellite system development.

Different categories of test data exist, with different life cycles. A universal categorization is not in use, but for the purposes of this document and the SATURN portal, the following terminology is used:

- Synthetic data: No scientific value, but realistic sizes and formats. Used for user dataflow testing.
- Simulated data: Data simulated by forward Radiative Transfer Model (RTM) calculations. Simulated 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.
- Proxy 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. Proxy data are used in early training on capabilities and application areas. It is also possible to use Proxy data to construct test data similar to simulated data

by adding RTM simulated data for channels to the ones present in pre-cursor missions 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, use consistent terminology to describe them, as well as provide software tools for the use of test data, both during pre-launch development and during post-launch commissioning activities.

5.5 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 targeted 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.

5.6 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 and continuing throughout the routine operations 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.

5.7 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. The WMO-CGMS VLab plays a key role in developing and delivering online training material to users worldwide in several languages. An event week on preparing for new-generation satellites was held in November 2015, to which NOAA, EUMETSAT, JMA, CMA, KMA all made contributions (presentations and recordings available at http://www.wmo-sat.info/vlab/next-generation-of-satelliles/); more events of this nature are planned by the VLab.

5.8 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).

6. 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 Satellite 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 instruments General description of NRT dissemination mechanisms. Detailed specifications of L2 and L1 products to be available at start of operations (Day-1 products). Proxy 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 and their performance, including planned SRFs, noise, FOV size. Simulated test data Detailed specifications of NRT dissemination mechanisms. Detailed specifications of Direct Broadcast (DB), including frequency and signal characteristics and hardware specifications for antennas, front-end components and computer systems for acquisition and processing of DB data. General description of offline data access. Data/product volume estimates. Data/product format definitions. Fundamental constants used in processing Data access conditions (e.g. licensing, key units, etc.). L1 pre-processing software for DB (preliminary version) Establish and use two-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.	Information on radiative transfer models (e.g., RTTOV) that support instruments Synthetic test data (including L1B data format details, Sat ID, navigation information) 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)	Full pre-launch instrument characterization information

Time relative to Launch Date ("L")	Satellite System Development: Activities and Milestones	User Readiness Project: Activities and Milestones	Needed Deliverables from Satellite Operators
			(including detailed SRFs, noise) 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).	Simulated test data based on pre-launch instrument characterization. L2 data format Direct Broadcast software package (if DB available) User documentation for dissemination mechanisms and delivered software tools. Routine operations schedule.
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. L1 pre-processing software for DB (operational version) Start of routine User Support
L+6m->L+2y	Commissioning of L2 products	Scientific data exploitation (iterative based on increased understanding of real data). Post-launch training based on real data. Declaration of user operational readiness	Operational L1 data dissemination, from both old and new satellites (as long as possible, but minimum until L+1y).