



Geostationary Operational Environmental Satellite (GOES) – R Series

ABI L2 Cloud and Moisture Imagery Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)

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ABI L2 Cloud and Moisture Imagery Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)

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Preface

The Readiness, Implementation, and Management Plans (RIMPs) have been created to document the analysis techniques, methodology, duration, tools, data, resources, staffing, and schedule of the Post-Launch Product Tests (PLPTs) to be used by the calibration and validation (cal/val) science teams to demonstrate the different levels of product maturity. The primary purpose of the RIMPs is to act as a planning resource for the cal/val teams as they prepare for Launch. Additionally, the RIMPs can be used by other members of the GOES-R Program to prepare for cal/val activities, to assess the suitability of the cal/val test plans, and to understand the science teams' data and resource requirements. Cal/val testing is likely to reveal necessary algorithm and/or look-up table (LUT) changes to evolve the product quality through the maturity levels. The Algorithm Change Management Plan (ACMP) will be used to track and implement these algorithm changes.

The evolving cal/val maturity of GOES-R products throughout the beginning of the mission is described by three levels: Beta, Provisional, and Full Validation. The Flight Project is responsible for producing the Level 1b (L1b) products according to the GOES-R Level III requirement documents. Once Beta maturity of the L1b products is achieved, validation activities for Level 2+ (L2+) products can begin. Further levels of maturity (Provisional and Full Validation) require additional and often long-term activities. A detailed description of the three product maturity levels is given in Figure 1, but a brief description of the three maturity levels are:

Beta: the product is minimally validated and may still contain significant errors; based on product quick looks using the initial calibration parameters.

Provisional: product performance has been demonstrated through a select number of independent measurements and periods. The analysis is sufficient to communicate product performance to end users, and the product is ready for operational use.

Full: product performance has been demonstrated over a large and wide range of representative conditions, with comprehensive documentation of product performance, including known anomalies and their remediation strategies. The product is operational.

Product quality assessment and declaration of maturity levels is performed during Peer Stakeholder-Product Validation Reviews (PS-PVRs). At each PS-PVR, the status of products will be presented by members of the cal/val science teams. For L1b products, Beta maturity PS-PVRs are held once each instrument's Post-Launch Tests (PLTs) have been successfully completed by the GOES-R Flight Project and the instrument vendors. Note that for GOES-18 and GOES-19, Beta maturity will be declared based on the quality assessment needed for the first public image/data release. After an L1b product has achieved Beta maturity, the product is added to the GOES Rebroadcast (GRB) stream. After an L1b or L2+ product has achieved Provisional maturity, the product is approved for distribution from Product Distribution and Access (PDA) and Comprehensive Large Array-data Stewardship System (CLASS). The review panel at the PS-PVRs will include the GOES-R Operational Readiness Working Group (GORWG), GOES-R Program System Engineering (PSE), NOAA Office of Satellite and Product Operations (OSPO), National Weather Service (NWS), and GOES-R Product Readiness and Operations (PRO).

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PS-PVR artifacts will be publicly available at https://www.noaasis.noaa.gov/GOES/product_quality.html.

The introspection necessary to create these RIMPs has led to extensive consultations between the cal/val teams and other groups within the GOES-R Program, including Program System Engineering, the Flight Project and the Ground Segment. Figure 2 below describes the responsibilities and accountability of each of the main parties involved in the creation of the RIMPs. This delineation is required because GOES-R operations are to be handed over from the GOES-R Program to NOAA OSPO at the end of the PLT period, yet the process of validating product maturity will continue. This changing nature of accountability during the process must be acknowledged. Accountability of the RIMPs changes at Operations Handover from NASA to NOAA and is aligned with the level of each RIMP's validation maturity objective. Accountability describes which organization owns documentation, process, and procedures. Responsibility describes which organization creates, executes, and maintains specific activities.

<u>GOES-R Product (L1b and L2+) Maturity Levels</u>
<p style="text-align: center;"><u>Beta Validation</u></p> <p><u>Preparation Activities</u></p> <ul style="list-style-type: none">○ Initial calibration applied (L1b).○ Rapid changes in product input tables, and possibly product algorithms, can be expected.○ Product quick looks and initial comparisons with ground truth data (if any) are not adequate to determine product quality.○ Anomalies may be found in the product and the resolution strategy may not exist. <p><u>End State</u></p> <ul style="list-style-type: none">○ Products are made available to users to gain familiarity with data formats and parameters.○ Product has been minimally validated and may still contain significant errors.○ Product is not optimized for operational use.
<p style="text-align: center;"><u>Provisional Validation</u></p> <p><u>Preparation Activities</u></p> <ul style="list-style-type: none">○ Validation and quality assurance (QA) activities are ongoing, and the general research community is now encouraged to participate.○ Severe algorithm anomalies are identified and under analysis. Solutions to anomalies are in development and testing.○ Incremental product improvements may still be occurring.○ Users are engaged in the Customer Forums (L2+ products only), and user feedback is assessed. <p><u>End State</u></p> <ul style="list-style-type: none">○ Product performance (L1b or L2+) has been demonstrated through analysis of a small number of independent measurements obtained from selected locations, periods, and associated ground-truth/field program efforts.○ Product analysis is sufficient to communicate product performance to users relative to expectations.○ Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, tested, and shared with the user community.○ Testing has been fully documented.○ Product ready for operational use and for use in comprehensive calibration/validation activities and product optimization.
<p style="text-align: center;"><u>Full Validation</u></p> <p><u>Preparation Activities</u></p> <ul style="list-style-type: none">○ Validation, QA, and anomaly resolution activities are ongoing.○ Incremental product improvements may still be occurring.○ Users are engaged and user feedback is assessed. <p><u>End State</u></p> <ul style="list-style-type: none">○ Product performance for all products is defined and documented over a wide range of representative conditions via ongoing ground-truth and validation efforts.○ Products are operationally optimized, as necessary, considering mission parameters of cost, schedule, and technical competence as compared to user expectations.○ All known product anomalies are documented and shared with the user community.○ Product is operational.

Figure 1. GOES-R product maturity levels.

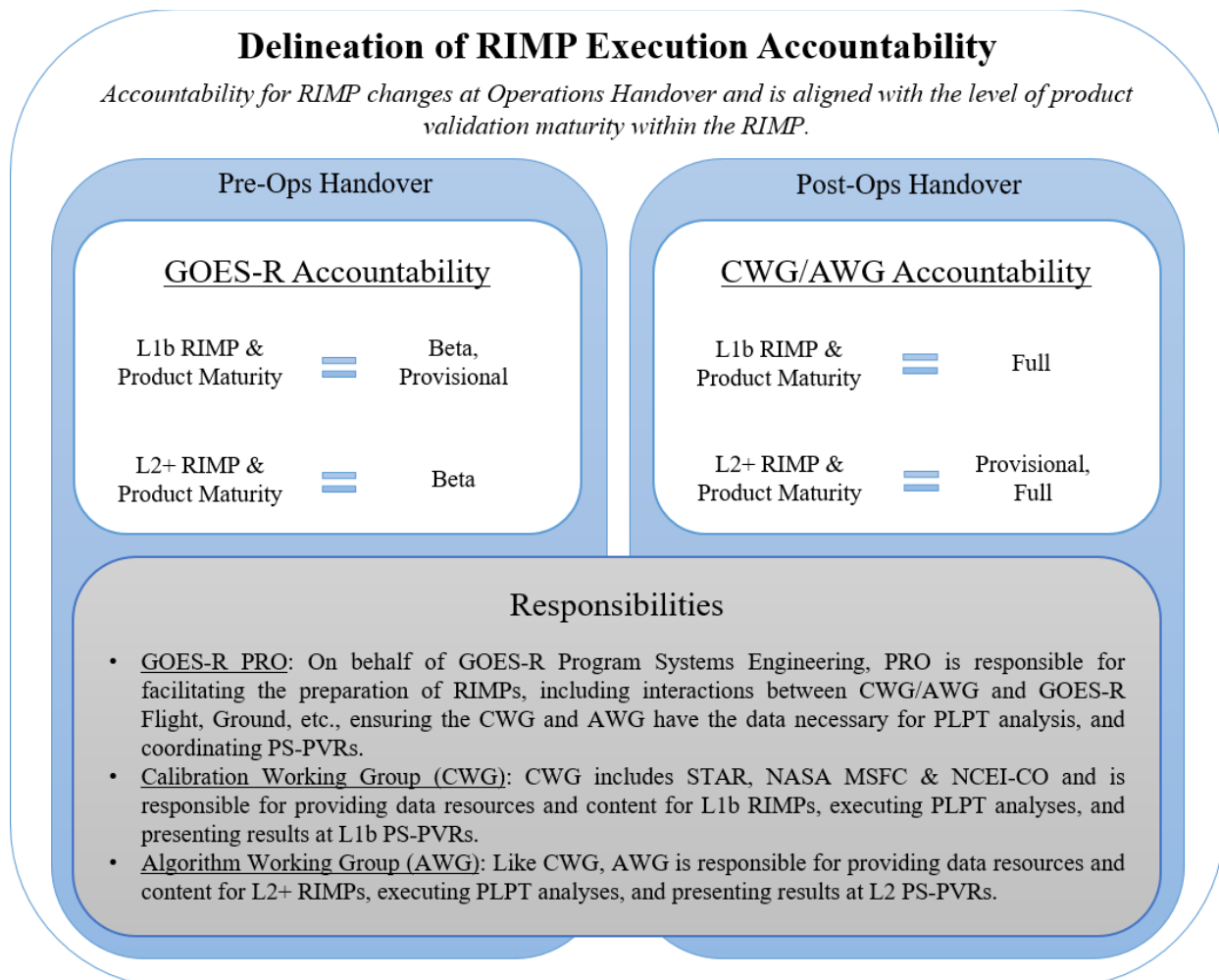


Figure 2. Delineation of RIMP execution accountability between GOES-R and CWG/AWG.

1. Cloud and Moisture Imagery Validation Overview

This Readiness, Implementation, and Management Plan (RIMP) covers all validation stages for GOES-R Advanced Baseline Imager (ABI) Cloud and Moisture Imagery (CMI) L2 product. CMI is hereafter referred to as “Imagery.” There are three stages in the validation process: Beta, Provisional, and Full. Each stage is defined by Post-Launch Product Tests (PLPTs), which guide the overall validation process. The RIMP includes a summary of the methods and tools employed to demonstrate that Imagery has met a given validation stage. Appendices are included that present more detail on each applicable PLPT and on the different data sets utilized in the Imagery validation process.

Table 1 shows a summary of the Imagery PLPTs and their execution status for each satellite and maturity level. There are two main test categories: one for verifying cadences and one for determining the quality of the conversion from radiance to reflectance factor/brightness temperature. Each category is tested for each scan type: Full Disk (FD), contiguous United States (CONUS), and mesoscale (MESO).

Unlike other L2 products, Imagery does not contain a “ground truth”. Reference data employed will be of two general types: the original L1b input and Imagery from the same bands from on-orbit GOES-R Series ABI (secondarily, similar bands on other satellites). The former is used to verify the Imagery is properly derived from the input, while the latter verifies the GOES-R Imagery may be employed in a manner consistent with operations today using ABI on other GOES-R Series satellites.

Table 1. PLPT test IDs, short descriptions, and execution status for each satellite(GOES-16, -17, and -18/-19), with a "B" indicating the test is required (or was done) for Beta maturity, a "P" indicating the test is required (or was done) for Provisional maturity, and an "F" indicating the test is required (or was done) for Full maturity.

Test ID	Short description	16	17	18/19
ABI-FD_CMI01	Verify FD product is generated every 10 minutes, for each ABI band, in Mode 6	B	B	P
ABI-CONUS_CMI02	Verify CONUS product is generated every 5 minutes, for each ABI band, in Mode 6	B	B	P
ABI-MESO_CMI03	Verify MESO product is generated every 30 seconds, for each ABI band, in Mode 6	B	B	P
ABI-FD_CMI04	Verify FD product is generated every 5 minutes, for each ABI band, in Mode 4	B	B	P
ABI-FD_CMI05	Assess the quality of the conversion from radiance to reflectance factor/brightness temperature of the Imagery FD product for each ABI band	B, P, F	B, P, F	P, F
ABI-CONUS_CMI06	Assess the quality of the conversion from radiance to reflectance factor/brightness temperature of the Imagery CONUS product for each ABI band	B, P, F	B, P, F	P, F
ABI-MESO_CMI07	Assess the quality of the conversion from radiance to reflectance factor/brightness temperature of the Imagery MESO product for each ABI band	B, P, F	B, P, F	P, F

Beta Maturity

As the only Key Performance Parameter (KPP) for the GOES-R Series, Imagery follows the ABI L1b portion of the validation schedule. As noted in Table 1, Beta PLPTs were required for GOES-16 and GOES-17 Imagery, but are not required for the subsequent satellites of the GOES-R Series. Instead, the GOES-18 and GOES-19 ABI L1b and Imagery products will be declared Beta after completion of select PLTs and agreement between various stakeholders, including Flight, PRO, CWG, AWG, PSE, the Mission Operations Support Team (MOST), and Program Science. The first public image release will coincide with this milestone.

Provisional Maturity

The Imagery product at Handover to OSPO is to be, at a minimum, at the Beta stage of validation (i.e., ABI L1b data have reached Beta maturity), with the goal of reaching Provisional by Handover. For Provisional, Imagery must be suitable for operational use, whether those users obtain Imagery from GOES Rebroadcast (GRB) direct readout or from the GOES-R ground system product distribution services such as PDA and AWIPS.

Table 2 identifies the frequency of each scan type for Modes 4 and 6. It includes the required cadence of the Imagery product as defined by both the GOES-R Functional and Performance Specification (F&PS) and the Product Definition and Users' Guide (PUG). The bottom line of the

table (Verif Freq) reflects, for each appropriate scan type, the frequency of that product used for verification purposes.

Table 2. Imagery documented product and verification cadence.

Mode	Mode 4			Mode 6		
	FD	CONUS	Mesoscale	FD	CONUS	Mesoscale
Scan Freq	5 min	5 min*	N/A	10 min	5 min	30 sec
F&PS	5 min	5 min	N/A	10 min	5 min	30 sec
PUG	5 min	5 min	N/A	10 min	5 min	1 min/30 sec#
Verif Freq	5 min	5 min	N/A	10 min	5 min	30 sec

* There is no CONUS scan type for Mode 4, but there are required products over the CONUS that are derived from the FD output

The refresh rate for mesoscale products applies to each of the two mesoscale scenes in ABI Mode 6. A 30 second refresh rate is provided if the two mesoscale scenes are geographically coincident.

The cadence tests, originally executed as Beta PLPTs for Imagery, will continue to be executed within the first week of the Post-Launch Test (PLT) period, but will only be required to be reported on at the Provisional PS-PVR.

Beyond the four cadence tests, there are three additional Provisional PLPTs to assess the quality of the Imagery product, specifically the conversion from radiance to reflectance factor/brightness temperature, for the three scan types (FD, CONUS, and mesoscale) under both Modes 4 and 6 as appropriate. For Imagery, this entails quantitative assessment via comparisons between L1b data and the reflectances/brightness temperatures for all spectral bands present in the Imagery product itself.

To declare Provisional maturity, the PLPTs must validate that the temporal and navigational consistency is adequate for operational Imagery applications and that the quality of the Imagery compares appropriately to expectations. The Provisional PLPT events last at least 5 weeks and commence immediately after Beta has been attained for the ABI L1b data. The NWS, as the primary Imagery user, will provide their feedback to the Imagery team, and will present their assessment of the product at the Provisional PS-PVR. PLPT events that support Provisional maturity are summarized in Table 1, and the details of each PLPT are described in Appendix A.

Due to the loop heat pipe anomaly on GOES-17, the GOES-17 Provisional PS-PVRs focus on data from the “cool” times of day when ABI L1b data are minimally impacted by elevated or drifting focal plane module temperatures. An additional Delta Provisional PS-PVR will be held for the GOES-17 ABI L2+ products (not including Imagery) to assess the quality of those products during the “warm” periods when the ABI L1b data are affected by saturation, bias, and increased noise in MWIR/LWIR bands 8-16 due to the loop heat pipe anomaly.

Full Maturity

For the Full Validation stage, the only additional consideration compared to the Provisional stage is the use of a more complete and thorough data set. Twelve months of additional Imagery is required to meet this purpose. These additional data allow for evaluation under most, if not all, conditions where Imagery is applied. Completion of the Full Validation stage verifies not only that the Imagery is sufficient for users, but most phenomena expected to be identified by Imagery has been verified to do so. Imagery from the ground system delivered via PDA will be the primary data source for Full PLPTs, and Imagery derived from the GRB will be used as an additional consideration. The methods and tools necessary for assessing the product for Full Validation are the same as those for proving Provisional. PLPT events that support Full maturity are shown in Table 1; details of each PLPT are in Appendix A.

The validation schedule, roles and responsibilities, monitoring and analysis methods, tools, and expected output artifacts are described in the following sections. The details of the PLPTs are in Appendix A, reference data sets are listed in Appendix B, and tools are described in Appendix C.

2. Schedule of Events

Figure 3 shows the high-level GOES-R Series validation schedule. Table 3 breaks down the schedule specifically for the Imagery product for all satellites in the GOES-R Series. As the only KPP for the GOES-R Series, Imagery follows the ABI L1b portion of the validation schedule and takes precedence over other ABI L2+ products.

Starting with GOES-17, all other ABI L2+ products reach Beta maturity automatically once ABI L1b radiance and Imagery reach Beta maturity. The ABI L1b and Imagery products are then evaluated for Provisional maturity with the Provisional PS-PVR held prior to Launch (L) plus 6 months.

After ABI L1b radiance and Imagery reach Provisional maturity, a 12 month Full Validation period for ABI L1b and Imagery begins. This is coincident with the start of the six month Provisional evaluation for the other ABI L2+ products, which is followed by another 12 month period for all other ABI L2+ products to achieve Full Validation, approximately 18 months after Handover.

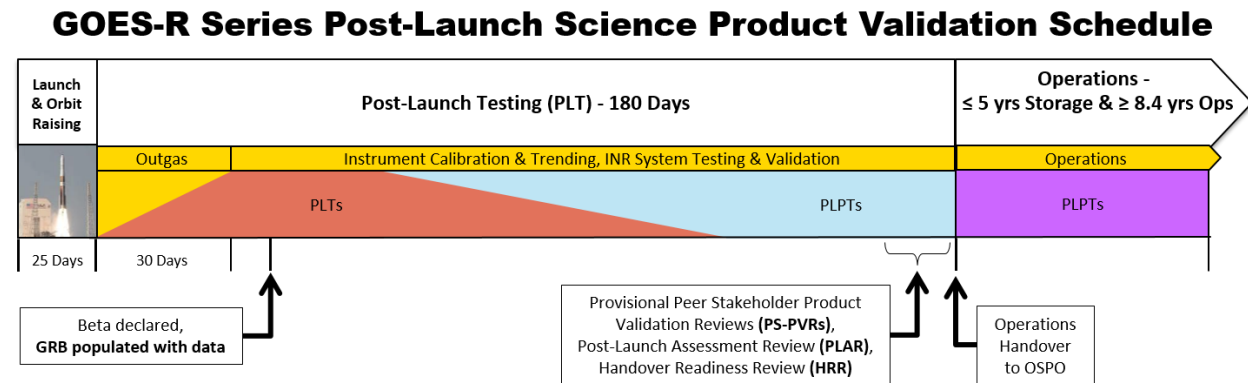


Figure 3. GOES-R Series schedule of events.

Table 3. Post-launch science product validation schedule for ABI L2 CMI (Imagery). The first column shows the nominal schedule in time from launch (L) plus months. The second column shows the same for days. The GOES columns with colored cells denote actual date, while the white cells denote expected date; the values in parentheses show L+days.

	Nominal (months)	Nominal (days)	GOES-16	GOES-17	GOES-18	GOES-19
Launch	L+0	L+0	11/19/16 (L+0)	3/1/18 (L+0)	12/7/21	4/1/24
Outgas complete	L+2	L+60	1/9/17 (L+51)	4/28/18 (L+58)	2/7/22	6/1/24
Beta	L+3	L+90	2/28/17 (L+101)	8/27/18 (L+179)	3/7/22	7/1/24
Provisional	L+6	L+180	6/1/17 (L+194)	11/28/18 (L+272)	6/7/22	10/1/24
Full	L+18	L+545	6/1/18 (L+559)	2/19/20 (L+720)	6/7/23	10/1/25

2.1 Beta Maturity Testing

For GOES-16 and GOES-17 a Beta PS-PVR was held to determine if the ABI L1b and Imagery products demonstrate on-orbit performance adequate to begin detailed product testing. For GOES-18 and GOES-19 there will be a Beta Certification but not a Beta PS-PVR. Beta Certification for the ABI L1b radiance and Imagery products will be given with the first public image release. Beta maturity is expected to be achieved no later than L+90 days. One day after Beta maturity is declared, GRB will be populated with the ABI L1b data.

2.2 Provisional Maturity Testing

2.2.1 Provisional Entrance Criteria:

PLPT activities begin during Flight-led PLT activities - when the detectors are cool and stable and BDS upload is complete - expected no later than L+90 days. Straightforward access to all Imagery products will be critical to achieving Provisional; issues with data access will directly impact the schedule of Imagery validation activities.

2.2.2 Duration of Provisional Testing:

Imagery PLPT events are expected to last at least 5 weeks. The first stage of PLPTs involve checking the cadence for each scan type, and will take 1 week to complete. Simultaneously, but to continue through the entire Provisional period, the Imagery will be evaluated for proper temporal and navigational consistency from image to image.

2.2.3 Provisional Testing Artifacts:

A presentation with supporting images that show the results of the PLPTs. These results include: Confirmation that Imagery is being produced at the proper cadence for each of the FD, CONUS, and mesoscale scan types and for each GOES-R ABI band; verification of proper conversion of radiance to reflectance factor or brightness temperature; quantitative comparisons between GOES-R Imagery produced by the ground system and that produced through the GRB direct readout system to determine if issues exist with either approach. See Section 6 (Output Artifacts) for more artifact details.

2.2.4 Exit Criteria and Readiness for Provisional PS-PVR:

The general criterion for Provisional product maturity is that the demonstrated product quality is deemed adequate for transfer to customer operations and generation of routine weather data products, to be completed no later than L+180 days. See Section 1 (Overview) and Appendix A (Post-Launch Product Tests) for more details on the individual PLPT success criteria.

Collating PLPT results and preparing reports and presentation materials for the Provisional PS-PVR should be done on a rolling basis from Beta onwards so long as Provisional testing is underway. An ABI L1b & Imagery PS-PVR will be convened with all the stakeholders before ABI L1b & Imagery products Handover to Operations at L+180 days.

2.3 Full Maturity Testing

2.3.1 Full Entrance Criteria:

Full Validation testing is a continuation of Provisional testing. If the satellite has gone into storage immediately after Provisional Validation, Full maturity PLPTs will start after the satellite is moved out of storage location.

2.3.2 Duration of Full Testing:

A minimum of one year of testing with Provisional maturity data is required for Full maturity validation. An XV (“Extended Validation”) period of 6 months was an explicit phase of GOES-16 pre-Operational testing. There is no XV phase for the subsequent satellites.

2.3.3 Full Testing Artifacts:

A presentation with supporting images that show the results of the Full maturity PLPTs. The Full PLPTs are a continuation of Provisional PLPTs, now over a wide range of representative conditions, e.g., testing over a full year of meteorological seasons in both hemispheres.

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2.3.4 Exit Criteria and Readiness for Full PS-PVR:

Product performance is defined, product is operationally optimized, and all known product anomalies are documented and shared with the user community. Full Validation is expected by L+545 days if the satellite is not placed into storage.

3. Roles and Responsibilities

The GOES-R Calibration/Validation Plan Volume 2: L2+ Product Validation (cal/val plan) is the governing document defining organizational responsibilities for GOES-R Imagery product testing, including the analysis, review, approval, and anomaly resolution processes required for product validation. The cal/val plan takes precedence over the following summary of specific post-launch test responsibilities.

PLT assessments of ABI instrument functionality, non-nominal operations, and initial data quality are conducted by MOST with vendor support by L3Harris-ABI. ABI L1b and Imagery will achieve Beta Validation during these early PLT assessments. Subsequent PLPT activities to advance the Imagery product maturity to Provisional Validation involves detailed data analysis conducted under guidance of the AWG and GOES-R Program management by members of the cal/val team at NOAA, NASA, and industry. Specific individuals and organizations responsible for advancing Imagery maturity are listed in Table 4 (names and affiliations subject to change).

Table 4. Imagery roles and responsibilities.

Role	GOES-16	GOES-17	GOES-18/19
CMI PLPT Lead	Timothy Schmit (STAR)	Timothy Schmit (STAR)	Timothy Schmit (STAR)
GOES-R Product Quality Lead	Jon Fulbright (PRO)	Elizabeth Kline (PRO)	Elizabeth Kline (PRO)
Product Area Lead	Wayne Mackenzie (PRO)	Thomas Feroli (PRO)	Thomas Feroli (PRO)
PLPT Test Analysts/Engineers	Mathew Gunshor (CIMSS); Kaba Bah (CIMSS)	Mathew Gunshor (CIMSS)	Mathew Gunshor (CIMSS)
CMI Product Quality Feedback	Timothy Schmit (STAR)	Timothy Schmit (STAR)	Timothy Schmit (STAR)
Remote Access	Jon Fulbright (PRO)	Janet Larson (PRO)	Janet Larson (PRO)
PASS/eGRES Requests	Wayne Mackenzie (PRO)	Stephen Superczynski (PRO)	Stephen Superczynski (PRO)

4. Tools

The Imagery validation effort primarily uses the McIDAS-X software package, with a number of scripts. Depending on the data to be analyzed, other freely available tools such as Geo2Grid, McIDAS-V, Panoply, or ncview may be used, or the commercially off-the-shelf MATLAB software. At a high-level, the tools are intended to address two fundamental aspects of Imagery validation. First, they mimic how an operational user would view GOES-R Series Imagery. Second, they intercompare GOES-R Series Imagery with that derived from other operational sources. The net capability thereby verifies the Imagery is at least as good as GOES-R predecessors and meets the needs of its users. The primary tools used for the analysis methods described in Section 5 are detailed in Appendix C.

5. Analysis Methods

5.1 Method 1

Visual inspection for both feature determination and image-to-image consistency will be the primary method of validating Imagery during the Provisional maturity stage by the Imagery team.

- Input from the NWS on ABI Imagery quality can be included as part of this method.
- Imagery has no quantitative requirements regarding the quality of the Imagery.
- Visual inspection will be used to identify artifacts that inhibit the use of Imagery, such as striping, banding, noise, or blur due to misalignment between bands.
- Visual inspection of looped GOES-R Series Imagery via McIDAS effectively shows any misalignments from temporally adjacent Images.
- Geographic features needed for this method are coastal areas, islands, rivers, and fires.

5.2 Method 2

Qualitative comparisons with Imagery derived from other on-orbit ABI will be used for Provisional and Full Validation. If deemed necessary, comparisons against polar-orbiter imagery may be used as a secondary assessment.

- The most critical comparison is between the Imagery product being validated and Imagery from other on-orbit ABI from the GOES-R Series, as they are the same instrument and will have a significant area of overlap during checkout.
- Images from polar-orbiting satellites will, at least twice a day, pass over the coverage area of GOES-R.
- Qualitative comparisons between GOES-R Imagery and that from simultaneous polar-orbiting satellites are useful in revealing atmospheric and ground elements and how well or poorly GOES-R Imagery may be used to diagnose these elements.
- McIDAS will be used for comparing Imagery from different sources.
- At a minimum, GOES-R must produce Imagery at least of similar quality to Imagery from other on-orbit ABI instruments of the GOES-R Series for the Provisional stage to be attained.

5.3 Method 3

Quantitatively compare GOES-R Imagery values (reflectances and brightness temperatures) between those obtained from the ground system and those produced from L1b radiances obtained by GRB direct readout for Provisional and Full Validation stages.

- This is the only quantitative analysis of use for validating Imagery.
- Quantitative statistics will be derived which reveal the correlation between the Imagery produced by the two systems.
- GLANCE will be used to generate these statistics.
- The statistical results will be included with the package that proves Provisional and Full Validation stages has been attained.

6. Output Artifacts

For Beta Validation, the output artifact will be the first public image release. Historically, this has been a full disk composite RGB color image, along with a 16-panel image of all the ABI spectral bands. For Provisional and Full Validation, the key artifacts for Imagery are presentation slide summaries, including images as needed. Any images indicative of a known issue are also key in the early stages of validation. Both single and multispectral imagery will be shown as output artifacts, as well as loops indicating the proper temporal consistency has been reached for both Mode 4 and Mode 6. Because Imagery has no quantitative requirements regarding its quality, the only statistical/quantitative output will be the correlation between GOES-R Imagery from the ground system and that derived from the GRB. These statistics are an artifact of the Provisional process. The slide decks covering the Provisional and Full Validation stages will include comparisons between on-orbit GOES-R Series ABI Imagery.

The delivery schedule of artifacts for the Imagery validation effort is tied to the schedule for completing each maturity level as given in Section 2. Presentations and associated images will be ready in time for the Provisional and Full PS-PVRs. After Imagery successfully passes each validation review, a ReadMe will be produced within two weeks.

7. References

The references listed below were used to generate this document, augmented with written and/or verbal feedback with the STAR AWG Imagery team. Unless otherwise noted, all documents with a “410-R” or “416-R” prefix are located in the GOES-R Library (in the Windchill repository).

Unless otherwise noted, the current versions of the following documents apply.

- 410-R-CALVAL-0192, GOES-R Series Calibration and Product Validation Strategy
- 410-R-CONOPS-0008, GOES-R Series Concept of Operations (CONOPS)
- 416-R-FPS-0089, GOES-R Series Ground Segment (GS) Project Functional and Performance Specifications (F&PS)
- 410-R-MRD-0070, GOES-R Series Mission Requirements Document (MRD)
- , 410-R-PLN-0194, GOES-R Series Calibration/Validation Plan Volume 2: Level 2+ Product Validation
- 416-R-PUG-L2 Plus-0349, Product Definition and User’s Guide (PUG) Volume 5: Level 2+ Products for GOES-R Core Ground Segment (L3Harris DCN-7035538)
- GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document for Cloud and Moisture Imagery Product (CMIP):
https://www.star.nesdis.noaa.gov/goesr/documents/ATBDs/Baseline/ATBD_GOES-R_ABI_CMI_KPP_v3.0_July2012.pdf

A. Appendix A: Post-Launch Product Tests

The point of contact (POC) for each PLPT is the CMI PLPT Lead unless otherwise noted in the individual test.

A.1 PLPT Events that Support Beta Maturity

None – Once ABI L1b has achieved Beta Maturity, Imagery will also be considered Beta.

A.2 PLPT Events that Support Provisional Maturity

A.2.1 Event Name: ABI-FD_CMI01

Objective: Verify that product is generated, for each ABI band, every 10 minutes for every FD.

Start Time: Start of PLT.

Duration: 1 week.

ABI Mode: Mode 6.

GOES-R Data Type(s): 10 minute FD.

Provisional Success Criteria: Product generated and falls within expected measurement range; all that is required for this PLPT is that the product is created and received at the validation site with a 10 minute cadence.

Dependencies: That the Imagery product is created by the ground system and delivery of such product to the cal/val team is sufficient to keep up with the cadence of the FD Imagery.

POC: PRO

Procedural References: Section 5, Method #1.

Comparison/Reference Data: B.1 and B.2.

Monitoring and Analysis Method: Product inspection, either the Imagery is produced at the correct cadence or it is not.

A.2.2 Event Name: ABI-CONUS_CMI02

Same as for ABI-FD_CMI01 except for:

GOES-R Data Type(s): 5 minute CONUS.

Provisional Success Criteria: The CONUS Imagery is generated and falls within expected measurement range; all that is required for this PLPT is that the product is created and received at the validation site with a 5 minute cadence.

A.2.3 Event Name: ABI-MESO_CMI03

Same as for ABI-FD_CMI01 except for:

GOES-R Data Type(s): 30 second mesoscale.

Provisional Success Criteria: The mesoscale Imagery is generated and falls within expected measurement range; all that is required for this PLPT is that the product is created and received at the validation site with a 30 second cadence. This includes the case where

2 mesoscale domains are running simultaneously. Both images would have to be created and received with the same 30 second cadence.

A.2.4 Event Name: ABI-FD_CMI04

Same as for ABI-FD_CMI01 except for:

ABI Mode: Mode 4.

Provisional Success Criteria: Product generated and falls within expected measurement range; all that is required for this PLPT is that the product is created and received at the validation site with a 5 minute cadence.

A.2.5 Event Name: ABI-FD_CMI05

Objective: Assess the temporal and navigational consistency of FD Imagery for operational applications, to include quantitative consistency between the input L1b data and the output reflectances/brightness temperatures in the Imagery output. Verify the time spacing is consistent from Image to Image, and that the geolocation does not jump from Image to Image such that a user who loops the Image could not follow features in the Image properly as they evolve over time.

Start Time: Immediately following Beta.

Duration: Until handover to OSPO.

ABI Mode: Mode 6.

GOES-R Data Type(s): 10 minute FD.

Provisional Success Criteria: Imagery has been analyzed for a sufficient number of cases to convey to users the quality of the Imagery products. The FD Images while looped do not exhibit egress discontinuities between successive Images. Moving features such as clouds exhibit a natural motion from one Image to the next, while stationary features (e.g., lakes) are truly stationary. Each and every band will be tested, and for all appropriate times (e.g., visual/NIR spectral bands only during daytime).

Dependencies: The Imagery product has reached the Beta stage of validation, and Imagery is available via the GRB.

Procedural References: Section 5, Methods #1, 2, and 3.

Comparison/Reference Data: GOES-R Imagery from the ground system and that derived from GRB, as well as time coincident Imagery from other on-orbit GOES-R Series satellites. If needed, secondary comparisons can be made with AVHRR, MODIS, and VIIRS.

Monitoring and Analysis Method: Product inspection; looping is a standard technique employed with geostationary Imagery and has been used for over 30 years. Additional insight provided from users.

A.2.6 Event Name: ABI-CONUS_CMI06

Same as for ABI-FD_CMI05 except for:

GOES-R Data Type(s): 5 minute CONUS.

A.2.7 Event Name: ABI-MESO_CMI07

Same as for ABI-FD_CMI05 except for:

GOES-R Data Type(s): 30 second mesoscale.

A.3 PLPT Events that Support Full Validation Maturity

A.3.1 Event Name: ABI-FD_CMI05

See the Provisional test description for ABI-FD_CMI05, with the following updates:

Objective: Assess the quality of the Imagery FD product, for each ABI band, over the entire range of representative conditions, to include quantitative consistency between the input L1b data and the output reflectances/brightness temperatures in the Imagery output; a minimum of 12 months of Provisional maturity Imagery output is required for this assessment.

Start Time: Immediately following Provisional.

Duration: Provisional plus 12 months.

Validated Success Criteria: Imagery has been analyzed for a significant number of cases to convey to users that, for all scenarios of interest to the users, the quality of the Imagery products is sufficient to identify features critical to the user.

Dependencies: The Imagery product has reached the Provisional stage of validation.

Monitoring and Analysis Method: Product inspection, similar to that used in Provisional but with significant insight from users.

A.3.2 Event Name: ABI-CONUS_CMI06

Same as the Full test description for ABI-FD_CMI05 except for:

GOES-R Data Type(s): 5 minute CONUS.

A.3.3 Event Name: ABI-MESO_CMI07

Same as the Full test description for ABI-FD_CMI05 except for:

GOES-R Data Type(s): 30 second mesoscale.

B. Appendix B: GOES-R Series and Validation Reference Data

B.1 Data Set #1: Name: ABI-L2-CMIP

Storage Location: SSEC Data Center.

Point of Contact: Jerrold Robaidek.

Access Process: Product Distribution and Access (PDA) or STAR.

Spatial Coverage: All modes: scan types - FD, CONUS, and mesoscale.

Temporal Coverage: All modes, 10 min for FD, 5 min for CONUS, 30 second for mesoscale.

Contingency: None, this is the Imagery product the team must validate, there is no validation without the core product.

Special Considerations: This product is the Imagery product for each band at its natural resolution.

B.2 Data Set #2: Name: ABI-L2-MCMIP

Storage Location: SSEC Data Center.

Point of Contact: Jerrold Robaidek.

Access Process: PDA or STAR.

Spatial Coverage: All modes: scan types - FD, CONUS, and mesoscale.

Temporal Coverage: All modes, 10 min for FD and CONUS, 5 min for mesoscale.

Contingency: None, this is the Imagery product the team must validate, there is no validation without the core product.

Special Considerations: This is the GOES-R multispectral Imagery product, i.e., all bands are available at the same resolution (2 km).

B.3 Data Set #3: Name: ABI-L1b-RAD (via GRB)

Storage Location: SSEC Data Center.

Point of Contact: Jerrold Robaidek.

Access Process: Direct readout – GRB.

Spatial Coverage: All modes: scan types - FD, CONUS, and mesoscale.

Temporal Coverage: All modes, 10 min for FD, 5 min for CONUS, 30 second for mesoscale.

Contingency: None, the cal/val of Imagery would proceed but no quantitative comparisons could be made for Imagery via the ground system and that derived from these radiances.

Special Considerations: None, these radiances should theoretically match those from the ground system, but as this is Imagery, the key is in the comparison of the Imagery products.

B.4 Data Set #4: Name: MODIS L1b

Storage Location: Science Investigator-led Processing System (SIPS).

Point of Contact: N/A (SIPS is co-located with the Imagery team).

Access Process: SIPS.

Spatial Coverage: GOES-R coverage area that is co-located with the MODIS sensor.

Temporal Coverage: All Imagery under Mode 4 or 6.

Contingency: Use other co-located Imagery from data sets 5 and 6.

Special Considerations: CIMSS has the ability to generate images from MODIS radiances, the actual comparisons of the resulting Imagery are through the McIDAS tools noted in Appendix C.

B.5 Data Set #5: Name: VIIRS Sensor Data Records (SDR)

Storage Location: Science Investigator-led Processing System (SIPS).

Point of Contact: N/A (SIPS is co-located with the Imagery team).

Access Process: SIPS.

Spatial Coverage: GOES-R coverage area that is co-located with the VIIRS sensor.

Temporal Coverage: All Imagery under Mode 4 or 6.

Contingency: Use other co-located Imagery from data sets 4 and 6 (GOES-16 and GOES-17 only).

Special Considerations: CIMSS has the ability to generate images from VIIRS radiances, the actual comparisons of the resulting Imagery are through the McIDAS tools noted in Appendix C. VIIRS SDRs may also be obtained from CLASS.

B.6 Data Set #6: Name: GOES L1b

Storage Location: Science Investigator-led Processing System (SIPS).

Point of Contact: N/A (SIPS is co-located with the Imagery team).

Access Process: SIPS.

Spatial Coverage: GOES-R coverage area that is co-located with heritage GOES sensor.

Temporal Coverage: All Imagery under Mode 4 or 6.

Contingency: Use other co-located Imagery from data sets 4 and 5.

Special Considerations: CIMSS has the ability to generate images from GOES radiances, the actual comparisons of the resulting Imagery are through the McIDAS tools noted in Appendix C. These heritage GOES data are only available as reference for GOES-16 and GOES-17; subsequent GOES-R Series satellites will use on-orbit GOES-R ABI data as reference instead.

C. Appendix C: Tools

C.1 Tool #1: Man-computer Interactive Data Access System version X (McIDAS – X)

Location: Cooperative Institute for Meteorological Satellite Studies (CIMSS).

Description: In house tool, though it is employed operationally by many outside of CIMSS; McIDAS allows Imagery, both single and multispectral, to be displayed as requested by its user. These displays include all of the data sets in Appendix B.

Developer: SSEC McIDAS Programmers.

Development Schedule and Handover Plan: Tool is ready for cal/val use with GOES-R.

Data Dependencies: GOES-R.

Testing Accomplished or Planned: Testing has been accomplished with surrogate, simulated, and on-orbit GOES-R Imagery.

POC: McIDAS User Services.

C.2 Tool #2: Man-computer Interactive Data Access System version V (McIDAS – V)

Location: CIMSS.

Description: In house tool, though it is employed operationally by many outside of CIMSS; McIDAS allows Imagery, both single and multispectral, to be displayed as requested by its user. These displays include all of the data sets in Appendix B. Version V allows for more user interaction than version X.

Developer: SSEC McIDAS Programmers.

Development Schedule and Handover Plan: Tool is ready for cal/val use with GOES-R.

Data Dependencies: GOES-R.

Testing Accomplished or Planned: Testing has been accomplished with surrogate, simulated, and on-orbit GOES-R Imagery.

POC: McIDAS User Services.

C.3 Tool #3: GLANCE

Location: CIMSS.

Description: GLANCE allows users to perform intercomparisons, in this case among Imagery from different sources, or between Imagery created from the same source but through different methods or with different inputs. Its key use for Imagery is to compare GOES-R Imagery obtained through the ground system with Imagery created from the same inputs but obtained from direct readout of the L1b radiances (direct readout via GRB), though it may be used with any derived imagery from the data sets in Appendix B.

Developer: CIMSS in collaboration with the Algorithm Integration Team (AIT).

Development Schedule and Handover Plan: CIMSS has completed development and it has been delivered to the AIT and Imagery team.

Data Dependencies: GOES-R, and possibly: VIIRS, MODIS, and AVHRR (Provisional only).

Testing Accomplished or Planned: AIT has completed its testing activities.

POC: AIT.

D. Appendix D: Acronyms

The acronym list below covers a select set of acronyms associated with CMI and general GOES-R procedures. To see a more comprehensive list of acronyms used within the GOES-R Program, see the GOES-R Series Acronyms webpage at <https://www.goes-r.gov/resources/acronyms.html>.

Acronym	Definition
AART	Algorithm Action Review Team
ABI	Advanced Baseline Imager
ADR	Algorithm Discrepancy Report
AIT	Algorithm Integration Team
ARM	Atmospheric Radiance Measurement
AVHRR	Advanced Very High Resolution Radiometer
AWG	Algorithm Working Group
Cal/Val	Calibration and Validation
CALIOP	Cloud-Aerosol Lidar with Orthogonal Polarization
CALIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
CATS	Cloud Aerosol Transport System
CCR	Configuration Change Request
CIMSS	Cooperative Institute for Meteorological Satellite Studies
CLASS	Comprehensive Large Array-data Stewardship System
CLAIR-X	Clouds from AVHRR - Extended
CMI	Cloud and Moisture Imagery
COD	Cloud Optical Depth
CONUS	Continental United States
COP	Cloud Optical Parameter
CPH	Cloud Phase
CPL	Cloud Physics Lidar
CPS	Cloud Particle Size
CRS	Cloud Radar System
CSM	Clear-Sky Mask
CWG	Calibration Working Group
DCOMP	Daytime Cloud Optical and Microphysical Properties
DOE	Data Operations Exercise
ER-2	Earth Resources 2
F&PS	GOES-R Functional and Performance Specification
FD	Full Disk
GeoCAT	Geostationary Cloud Algorithm Testbed
GOES	Geostationary Operational Environmental Satellite

Acronym	Definition
GOES-R	GOES-R Series
GORWG	GOES-R Series Operational Requirements Working Group
GRB	GOES Rebroadcast
IR	Infrared
JPSS	Joint Polar Satellite System
L1b	Level 1b
L2	Level 2
LWIR	Longwave Infrared
LZSS	Level Zero Storage Solution
McIDAS	Man-computer Interactive Data Access System
MODIS	Moderate Resolution Imaging Spectroradiometer
MOST	Mission Operations Support Team
MSFC	Marshall Space Flight Center
MUG	McIDAS User's Group
MWIR	Mid-Wave Infrared
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NCEI	National Centers for Environmental Information
NCEI-CO	NCEI - Colorado
NCOMP	Nighttime Cloud Optical and Microphysical Properties
NIR	Near Infrared
NLT	No Later Than
NWP	Numerical Weather Prediction
NWS	National Weather Service
OSPO	Office of Satellite and Product Operations
PDA	Product Distribution and Access
PLAR	Post-Launch Assessment Review
PLPT	Post-Launch Product Test
PLT	Post-Launch Test
POC	Point of Contact
PRO	Product Readiness and Operations
PSE	Program System Engineering
PS-PVR	Peer Stakeholder-Product Validation Review
PUG	Product User's Guide
QA	Quality Assurance
QC	Quality Control
RGB	Red-Green-Blue
RIMP	Readiness, Implementation and Management Plan
SDR	Sensor Data Records

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Version 2.0

Acronym	Definition
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SIPS	Science Investigator-led Processing System
SPOT	System Performance Operational Test
SSEC	Space Science and Engineering Center
STAR	Center for Satellite Applications and Research
SZA	Solar Zenith Angle
TBD	To Be Determined
VIIRS	Visible Infrared Imaging Radiometer Suite