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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Change Record

	DOCUMENT TITLE: ABI L2 Cloud and Moisture Imagery Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)			
VERSION	**DATE**	**CCR #**	**PAGES AFFECTED**	**DESCRIPTION**
1.0	09/02/2016	03177	All	Initial

The document version number identifies whether the document is a working copy, final, revision, or update, defined as follows:

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- **Update:** an edition with major changes from the previous edition, defined as changes affecting more than one-third of the pages in the document. The version number for an update is always a whole number (Version 2.0, 3.0, 4.0, and so forth).

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Preface

The evolving calibration and validation (cal/val) maturity of Geostationary Operational Environmental Satellite R-Series (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 Level III requirement documents. Once Beta Maturity of the L1b products is achieved, the Level 2+ (L2+) will begin analysis towards Beta maturity. 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 brief descriptions 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 large, but still (seasonally or otherwise) limited, number of independent measurements. The analysis is sufficient for limited qualitative determinations of product fitness-for-purpose, and the product is potentially ready for testing 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. Products are ready for operational use.

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 L2+ products, Beta maturity PS-PVRs are held in close proximity with and prior to Operations Handover. 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), and GOES-R Product Readiness and Operations (PRO). 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 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 data and resource requirements the science teams have. Cal/val testing is likely to reveal necessary algorithm 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 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 the Flight Project, the Ground Segment, and a team of experts from The Aerospace Corporation under contract from GOES-R PSE to help improve the cal/val mission. 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 RIMPs' validation maturity objective. Accountability determines which organization owns documentation, process, and procedures. Responsibility determines which organization creates, executes, and maintains specific activities.

GOES-R Product (L1b and L2+) Maturity Levels

Beta Validation

Preparation Activities
- 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.

End state
- 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.

Provisional Validation

Preparation Activities
- 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.

End state
- 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 are 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.

Full Validation

Preparation Activities
- Validation, QA, and anomaly resolution activities are ongoing.
- Incremental product improvements may still be occurring.
- Users are engaged and user feedback is assessed.

End state
- 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.

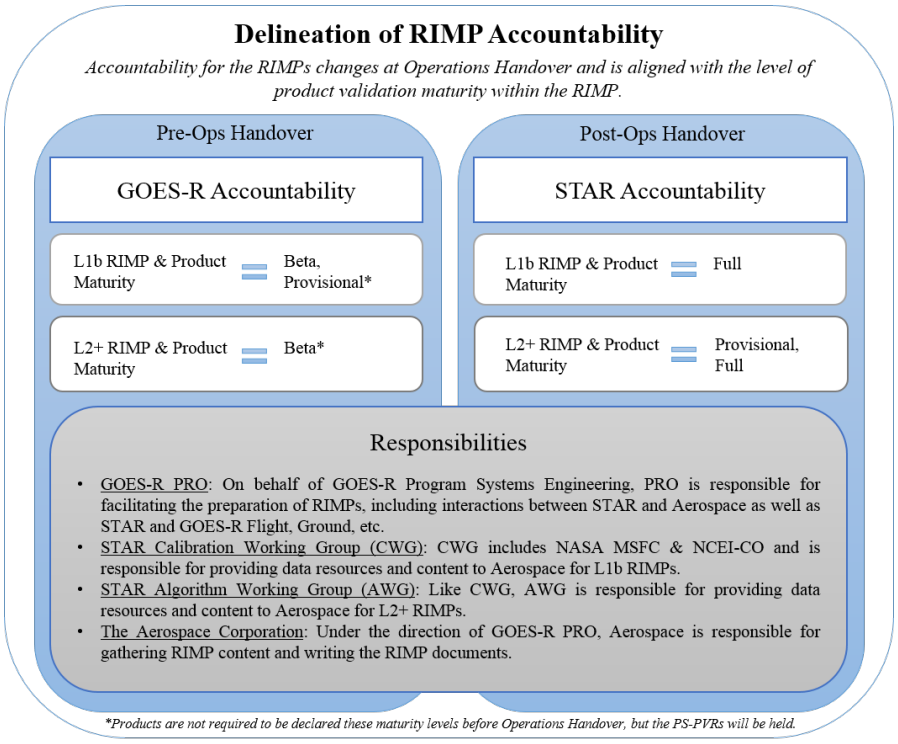

Figure 2. Delineation of accountability between GOES-R and STAR.

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 Fully Validated. Each stage is defined by PLPTs, which guide the overall validation process. The RIMP includes a summary of the methods and tools employed to prove Imagery has met a given validation stage. Appendices are included that present more detail on each applicable PLPT and detail on the different data sets employed in the Imagery validation process.

Imagery has seven PLT/PLPT events necessary to attain Beta maturity for the Imagery product. Three of these state the Imagery are created at Mode 3 for Full Disk (FD), CONUS, and mesoscale scans and they are generated at the frequencies required. One additional PLPT applies to FD in Mode 4. These four are all verified in the first week of the Post Launch Test (PLT). The other three involve the assessment of Imagery such that they contain adequate "temporal and navigational" consistency. These latter three events last approximately 5 weeks (TBR), occur in parallel, and also commence at the start of PLT.

Once Beta has been achieved, as a Key Performance Parameter (KPP), Imagery will move to accomplishing Provisional stage during PLPT, with the objective of completing Provisional by the time of handover to the Office of Satellite and Product Operations (OSPO). Three PLPTs must be accomplished to complete the Provisional stage. Each of these deals with the "accuracy and precision" of the Imagery product as applicable to the three scan types of operation (FD, CONUS, and mesoscale) under both modes 3 and 4 as appropriate – see Table 1. 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. The role of the users is also increased in determining if Provisional has been reached, as noted later in the document.[1,2] PLT events that support the Beta maturity are listed below; details are in Appendix A[1]:

- **ABI-FD_CMI01:** verify Full Disk (FD) product is generated every 15 minutes, for each ABI band, in Mode 3.
- **ABI-CONUS_CMI01:** verify CONUS product is generated every 5 minutes, for each ABI band, in Mode 3.
- **ABI-MESO_CMI01:** verify mesoscale product is generated every 30 seconds, for each ABI band, in Mode 3.
- **ABI-FD_CMI02:** verify Full Disk (FD) product is generated every 5 minutes, for each ABI band, in Mode 4.
- **ABI-FD_CMI04:** assess the initial temporal and navigational consistency, for each ABI band, of FD Imagery.
- **ABI-CONUS_CMI02:** assess the initial temporal and navigational consistency, for each ABI band, of CONUS Imagery.
- **ABI-MESO_CMI02:** assess the initial temporal and navigational consistency, for each ABI band, of mesoscale Imagery.

The following Table identifies the frequency of each scan type for Modes 3 and 4. 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 User's Guide (PUG). The bottom line reflects, for each appropriate scan type, the frequency of that product used for verification purposes.

** There is no CONUS scan type for Mode 4, but there are required products over the CONUS that are derived from the FD output*
 # Once mesoscale scans begin, the first image is after 1 minute, thereafter every 30 seconds, as documented in the PUG

Mode	Mode 3			Mode 4		
Scan Type	FD	CONUS	Mesoscale	FD	CONUS	Mesoscale
Scan Freq	15 min	5 min	30 sec	5 min	5 min*	N/A
F&PS	15 min	5 min	30 sec	5 min	5 min	N/A
PUG	15 min	5 min	1 min/30 sec#	5 min	5 min	N/A
Verif Freq	15 min	5 min	30 sec	5 min	5 min	N/A

Table 1. Imagery documented product and verification cadence.

Three events in the PLPT list have been defined to attain Provisional maturity for Imagery. To declare Provisional maturity, these events 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 approximately 5 weeks (TBR), occur in parallel, and commence immediately after Beta has been attained, with the objective of being completed by the time of handover to OSPO.[1,2] PLPT events that support Provisional maturity are listed below; details are in Appendix A[1]:

- **ABI-FD_CMI04:** assess the accuracy and precision of the Imagery FD product, for each ABI band, over a large and wide range of representative conditions, to include quantitative consistency between the input L1b data and the output reflectances/brightness temperatures in the Imagery output.
- **ABI-CONUS_CMI02:** assess the accuracy and precision of the Imagery CONUS product, for each ABI band, over a large and wide range of representative conditions, to include quantitative consistency between the input L1b data and the output reflectances/brightness temperatures in the Imagery output.
- **ABI-MESO_CMI02:** assess the accuracy and precision of the Imagery mesoscale product, for each ABI band, over a large and wide range of representative conditions, to include quantitative consistency between the input L1b data and the output reflectances/brightness temperatures in the Imagery output.

Moving to the final stage of validation, simply referred to as "Fully" Validated, the only additional consideration compared to the Provisional stage is the use of a more complete and thorough data set of Imagery. Six months of additional Imagery is adequate to meet this purpose, hence validated will be accomplished at launch plus 298 days (L+298 days). Completion of the 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 derived from the GOES Rebroadcast (GRB) will be used as an additional consideration. The methods and tools necessary for prove the Full Validation stage are the same as those for proving Provisional. This additional data allows for evaluation of Imagery under most, if not all, conditions where Imagery is applied. PLPT events that support Fully Validated maturity are listed below; details are in Appendix A[1]:

- **ABI-FD_CMI06:** assess the accuracy and precision 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 six months' worth of Imagery output is required for this assessment.
- **ABI-CONUS_CMI03:** assess the accuracy and precision of the Imagery CONUS 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 six months' worth of Imagery output is required for this assessment.

- **ABI-MESO_CMI03:** assess the accuracy and precision of the Imagery mesoscale 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 six months' worth of Imagery output is required for this assessment.

The validation processes, monitoring and analysis methods, tools, and expected output artifacts are described in the following sections. The details of each PLPT are contained in Appendix A and of each reference data set are in Appendix B. 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 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 these other satellites. As such, with regard to the latter, the highest priority is with heritage bands on GOES.

The Imagery at handover is to be, at a minimum, at the Beta stage of verification, with the goal of reaching Provisional at handover. Beta for Imagery is that the reflectances and brightness temperatures are properly derived from the L1b radiances, and that any issues with the Imagery are identified and properly documented. For Provisional, the Imagery must be suitable for operational users, whether they use the direct readout or the ground system as the source for GOES-R data. Note it is possible to pass Beta or Provisional criteria ahead of the L1b data itself. The specific criteria for GOES-R Imagery to attain Provisional are[1,2,9]:

- Assess the validity of each mode/scan type pair and each band for its Imagery over a large and wide range of representative conditions (including multiple times of the day).
- The Imagery products are deemed suitable for operational use by the primary user (National Weather Service (NWS)).
- Quantitative consistency exists between the L1b input data and the output reflectances/brightness temperatures in the Imagery output.
- GOES-R Imagery must be at least of comparable quality to the heritage bands on GOES.
- Report any incidents that are detected to the Algorithm Discrepancy Report (ADR) group for discussion by the Algorithm Action Review Team (AART).
- The same criteria apply to the Full Validation stage with the following additions:
    - The validity of the Imagery includes that basic operational needs are met (e.g., the imagery looks as expected).
    - The Imagery derived from the GRB is consistent with that from the ground system.
    - Any incidents related to Imagery in the ADR group are resolved.

2. Schedule of Events

Figure 3 shows the GOES-R validation schedule. System Performance Operation Test (SPOT) begins 44 days after launch when ABI L1b and the L2 Cloud and Moisture Imagery (CMI) Key Performance Beta evaluation begins and should be declared Beta maturity by L+87 days. One day later, GRB will be populated with that data. All L2 products must reach Beta maturity by handover at L+197 days, the same time that ABI L1b and CMI must reach Provisional. Given that L2 Beta tests require at least 6 weeks, L2 Beta testing must get underway by L+155 days, but can begin as soon as the ABI L1b and CMI reach Beta (L+87 days). The GOES-R Operations phase begins after handover marking the start of a 12 month Extended Validation period for ABI L1b and CMI, which is coincident with the start of the 6 month L2 Provisional evaluation, followed by another nine months period for all L2 products to become Fully Validated, 15 months after handover.

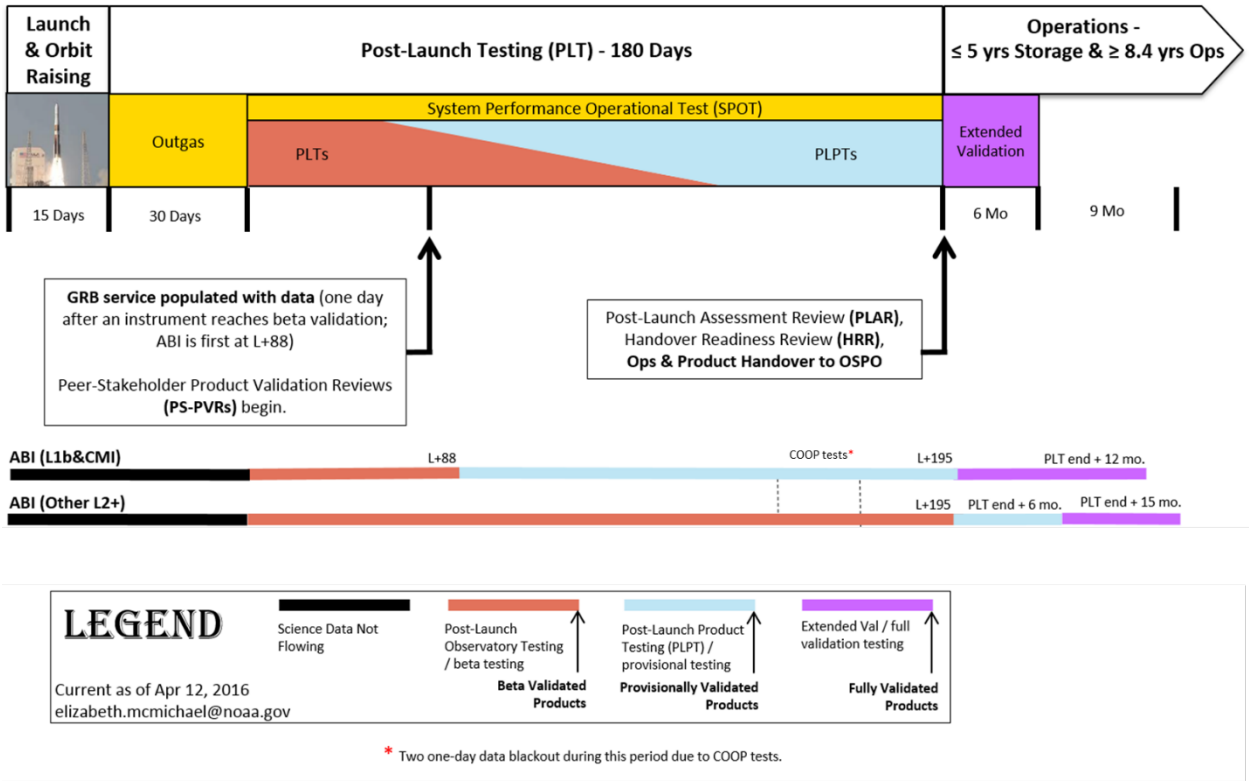

Figure 3. Schedule of events.

A schedule of specific Imagery validation activities includes:

- Current – July 2016: finish testing all Imagery related validation tools.
- Current – March 2016: evaluate results using output from DOE-3.
- July – September 2016: evaluate results using output from DOE 4
- September 2016: complete final versions of all Imagery validation tools.
- L+44 days: begin Beta validation phase (data may only be available via PDA).
- L+51 days: complete verification of cadence requirements (OSPO).
- L+87 days (or earlier): Finish Beta phase.
- L+88 days: begin Provisional phase (Imagery available via GRB).

- L+122 days: complete Provisional phase of validation (no later than date L+197 days).
- L+298 days: complete the final stage of validation (no later than date L+377 days).

Other aspects related to schedule include:

- As a KPP, Imagery follows the ABI (L1b and KPP) portion of the PLT/PLPT schedule.
- The initial Beta testing, which occurs at the start of PLT, will focus on the Imagery being produced at the proper cadence for each of FD, CONUS, and mesoscale scan types and for each GOES-R ABI band.[1]
- The first stage will take one week.[1]
- Simultaneously, but to continue through the entire Beta period, the Imagery will be evaluated for proper temporal and navigational consistency from image to image.[1,2,6,7]
- Additional Imagery will be brought in and/or produced at CIMSS to compare with that derived from GOES-R.[1,6,7]
- During Provisional, the proper conversion of radiance to reflectance factor or brightness temperature will be confirmed.[9]
- For Provisional only, quantitative comparisons between GOES-R Imagery produced by the ground system and that produced through the direct readout system will be used to determine if issues exist with either approach.[9]
- Straightforward access to all Imagery products will be critical to achieving Beta and Provisional, issues with data access will directly impact the schedule of Imagery validation activities.[9]
- As a Key Performance Parameter (KPP), the Imagery takes precedence over other L2+ products, since no other L2+ product is a KPP.[1,4]
- The determination of Imagery being Provisional is not tied to the status of any other product.
- Because Imagery does not strongly depend upon the quantitative accuracy of the input L1b data, it may pass Beta and/or Provisional stages of validation before the L1b does.
- In addition, when Imagery is at or near Beta (L+88 days), then the data can be sent via GRB, allowing for testing at GRB reception sites.
- Also as a KPP, Imagery is ideally to attain Provisional status at handover.[1,9]

3. Roles and Responsibilities

3.1 Primary Point of Contact

The primary point-of-contact (POC) for managing CMI is Tim Schmit.[1,6,7]

3.2 GOES-R Point of Contact

The primary POC at GOES-R for the Imagery validation effort is Wayne MacKenzie.

3.3 Test Analyst/Engineer

The test analysts will be Mat Gunshor and Kaba Bah.

3.4 GOES-R Feedback

Formal feedback to the GOES-R Program regarding the CMI Validation will be provided by Tim Schmit.

3.5 Level of Effort

The test analysts (Mat Gunshor and Kaba Bah), will work nearly full time (0.80 Full Time Equivalent for each) on the Imagery products during PLT/PLPT, that is, for all stages of validation.[9]

4. Tools

The Imagery validation effort utilizes a set of seven tools. 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 Imagery. Second, they inter-compare GOES-R 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. Each of these tools is 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 Beta and Provisional by the Imagery team[1,5,6,7]

- 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.[3]
- 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.[6,7]
- Visual inspection of looped GOES-R Imagery via McIDAS effectively shows any misalignments from temporally adjacent Images.[1]
- The primary features needed for this method are coastal areas, islands, rivers, and fires.[9]
- This is the only method employed during Beta.[9]
- Examples of any artifacts or other issues (misalignments) from these inspections will be shown as part of establishing Beta.[6,7]

5.2 Method 2

Qualitative comparisons with Imagery derived from GOES and polar-orbiters, Provisional and Full Validation only.[1,6,7]

- Images from polar-orbiting satellites will, at least twice a day, pass over the coverage area of GOES-R.[5,6,7]
- 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.[1]
- The most critical comparison is between GOES-R and GOES, as they cover the same area at all times.[9]
- Emphasis will be given to comparing the heritage bands on GOES with its counterpart on GOES-R.
- McIDAS will be used for comparing Imagery from different sources.[6,7]
- At a minimum, GOES-R must produce Imagery at least of similar quality to GOES for the Provisional stage to be attained.

5.3 Method 3

Quantitatively compare GOES-R Imagery values (reflectances and brightness temperatures) between that obtained from the ground system and that produced from L1b radiances obtained by direct readout, Provisional and Full Validation stages only.[9]

- This is the only quantitative analysis of use for validating Imagery.[9]
- Quantitative statistics will be derived which reveal the correlation between the Imagery produced by the two systems.[9]
- GLANCE will be used to generate these stastistics.[6,7]
- The statistical results will be included with the package that proves Provisional and Full Validation stages has been attained.

6. Output Artifacts

6.1 Beta Maturity Artifacts

The two criteria for declaring Beta maturity as indicated in Section 1 are: (1) quantitatively assess the performance of the GOES-R Imagery through verification of the resulting reflectances and brightness temperatures; and (2) identify any issues with the Imagery products via visual inspection. Performance and product issues will be documented in a Beta test report.[1,9]

The primary method to evaluate Imagery is the Imagery itself, as visual inspection is the primary evaluation technique.[1,6,7]

Both single and multi-spectral imagery will be shown as output artifacts, as well as loops indicating the proper temporal consistency has been reached, for both Mode 3 and 4.[1,9]

The number and scope of the artifacts at the end of Beta will be proportional to the number of issues identified.[9]

6.1.1 These tests of priority 1 (those tied to methods 1 and 2 for beta) all must pass.

6.1.2 There are no priority 2 tests for beta.

6.2 Provisional Maturity Artifacts

The criteria for declaring Provisional maturity include suitability for operational use by the primary user (NWS), quantitative consistency between the ground system and direct readout Imagery products, and quality either comparable to or better than the heritage bands on GOES.

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.[1,3,9]

The reports covering the Provisional stage will include comparative Imagery between GOES-R and GOES.

6.2.1 These tests of priority 1 all must pass.

6.2.2 There are no priority 2 tests for provisional.

6.3 Full Validation Maturity Artifacts

The criteria for declaring Full Validation maturity are the same as for Provisional, however the data set must cover all seasonal variations and cover all representative conditions of interest to users. To attain full validation, the correct system flight level Spectral Response Functions must be used.

The reports covering the Full Validation stage will include comparative Imagery between GOES-R and GOES.

6.3.1 These tests of priority 1 all must pass.

6.3.2 There are no priority 2 tests for reaching the fully validated stage.

6.4 Key Artifacts

Key artifacts for the CMI validation effort are power point summaries, including images as needed. Any images indicative of a known issue are also key in the early stages of validation.

6.5 More Output Artifacts

There are no additional artifacts for Imagery.

6.6 Delivery Schedule

The delivery schedule of artifacts for the CMI validation effort is tied to the schedule for completing beta, provisional, and full validation as given in section 2. Power point based presentations and associated images will be ready in time for the PS-PVR.

7. Pre-launch

- The verification of the format and data content of all Imagery products and the development/testing of the tools required for the analysis of Imagery was completed.[2,4,9]
- Output from DOEs were used to verify Imagery tools work with the appropriate GOES-R diagnostics, this is the only remaining item to be tested pre-launch.[9,11]
- Data flows for pre-launch testing were through STAR.[9]

8. References

The references listed below were used to generate this document, augmented with written and/or verbal feedback with the STAR product team. Superscripts are invoked within the text of this document to indicate a reference that can provide additional detail for the reader.

[1] Verification Event (VE) spreadsheet (PLPT_Validation_Event_List_L2_v0_1_20140903_with_Post-PLT_Entries).
[2] GOES-R Series Calibration/Validation Plan Volume 2: Level 2+ Product Validation.
[3] GOES-R Series Mission Requirements Document.
[4] GOES-R Series System – Level Calibration and Product Measurement Validation Concept of Operations (CONOPS) and Operational Concepts (OPSCON).
[5] GOES-R Post-Launch Product Testing Overview February 3, 2105.
[6] GOES-R AWG Algorithm Product Validation Tool Development, Imagery Application Team; 1st GOES-R Validation Workshop, May 10, 2011.
[7] GOES-R AWG Product Validation Tool Development (January 2014), Imagery ("the KPP") Application Team, 2nd GOES-R Validation Workshop, January 9, 2014.
[8] GOES-R Field Campaign, NOAA Satellite Science Week, February, 2015.
[9] Interviews with Imagery and Cloud Teams, June 2 and 3, 2015.
[10] www.class.noaa.gov (CLASS web site).
[11] Program Science Readiness Meeting 06022015.

A. Appendix A: Validation Events

A.1 PLPT Events that Support Beta Maturity

A.1.1 Event Name: ABI-FD_CMI01[1]

Objective: Verify that product is generated, for each ABI band, every 15 min for every FD.[3]
Start Time: Start of PLT.[1]
Duration: 1 week.[1]
ABI Mode: Mode 3.[1]
GOES-R Data Type(s): 15 min FD.[1]
Beta 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 15 min cadence.[1,3]
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.[1,4]
PLPT Lead: PRO[9]
PLPT Analyst: PRO[9]
Procedural References: Section 5, Method #1.
Comparison/Reference Data: B.1 and B.2.
Validation Data: None (quality assessed in a different PLPT).[1]
Monitoring and Analysis Method: Product inspection, either the Imagery is produced at the correct cadence or it is not.[1,3]

A.1.2 Event Name: ABI-CONUS_CMI01

Same as for ABI-FD_CMI01 except for:
GOES-R Data Type(s): 5 min CONUS.[1,3]
Beta 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 min cadence.[1]

A.1.3 Event Name: ABI-MESO_CMI01

Same as for ABI-FD_CMI01 except for:
GOES-R Data Type(s): 30 second mesoscale.[1,3]
Beta 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.[1]

A.1.4 Event Name: ABI-FD_CMI02

Same as for ABI-FD_CMI01 except for:
ABI Mode: Mode 4.[T]
Beta 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 the correct cadence.[1,3]

A.1.5 Event Name: ABI-FD_CMI04

Objective: Determine the initial consistency of the temporal and navigational characteristics of GOES-R FD Imagery. 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.[1,9]
Start Time: Start of PLT.[1]
Duration: All of PLT, or until Beta is reached.[1]
ABI Mode: Mode 3.[1]
GOES-R Data Type(s): 15 min FD Imagery.[1,3]
Beta Success Criteria: 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).[5,6,7]
Dependencies: inspection of Imagery FD products in a sequential manner, sufficient to reveal image-to-image consistency.[1]
PLPT Lead: Tim Schmit.[6,7]
PLPT Analyst: Mat Gunshor and Kaba Bah.[9]
Validation Data: GOES-R Imagery.[1,9]
Procedural References: Section 5, Method #1.
Comparison/Reference Data: B.1, B.2, B.4, B.5, B.6, and B.7.[9]
Monitoring and Analysis Method: Product inspection; looping is a standard technique employed with geostationary Imagery and has been used for over 30 years.[1,5]

A.1.6 Event Name: ABI-CONUS_CSM02

Same as for ABI-FD_CMI04 except for:
GOES-R Data Type(s): 5 min CONUS Imagery.[1,3]

A.1.7 Event Name: ABI-MESO_CSM02

Same as for ABI-FD_CMI04 except for:
GOES-R Data Type(s): 30 second mesoscale Imagery.[1,3]

A.2 PLPT Events that Support Provisional Maturity

A.2.1 Event Name: ABI-FD_CMI04[1]

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.[1]
Start Time: Immediately following Beta.[1]
Duration: Until handover to OSPO[1]
ABI Mode: Mode 3.[1]
GOES-R Data Type(s): 15 min FD.[1]
Provisional Success Criteria: Imagery has been analyzed for a sufficient number of cases to convey to users the quality of the Imagery products.[1,3]
Dependencies: The Imagery product has reached the Beta stage of validation, and that Imagery is now available via the GRB.[1,2,4]
PLPT Lead: Tim Schmit.[9]
PLPT Analyst: Mat Gunshor and Kaba Bah.[9]
Procedural References: Section 5, Methods #1, 2, and 3.
Comparison/Reference Data: All data sets noted in Appendix B.[9]
Validation Data: GOES-R Imagery from the ground system and that derived from GRB, as well as time coincident Imagery from GOES, AVHRR, MODIS, and VIIRS.[6,7,9]
Monitoring and Analysis Method: Product inspection, similar to that used in Beta but with additional insight from users.[1,2,5]

A.2.2 Event Name: ABI-CONUS_CMI02

Same as for ABI-FD_CMI04 except for:
GOES-R Data Type(s): 5 min CONUS.[1,3]

A.2.3 Event Name: ABI-MESO_CMI02

Same as for ABI-FD_CMI04 except for:
GOES-R Data Type(s): 30 second mesoscale.[1,3]

A.3 PLPT Events that Support Full Validation Maturity

A.3.1 Event Name: ABI-FD_CMI06[1]

Objective: Assess the accuracy and precision 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 six months of Imagery output is required for this assessment.[1]
Start Time: Immediately following Provisional.[1]
Duration: Until one year after launch.[1]
ABI Mode: Mode 3.[1]
GOES-R Data Type(s): 15 min FD.[1]
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.[1,3]
Dependencies: The Imagery product has reached the Provisional stage of validation.[1,2,4]
PLPT Lead: Tim Schmit.[9]
PLPT Analyst: Mat Gunshor and Kaba Bah.[9]
Procedural References: Section 5, Methods #1, 2, and 3.
Comparison/Reference Data: All data sets noted in Appendix B.[9]
Validation Data: GOES-R Imagery from the ground system and that derived from GRB, as well as time coincident Imagery from GOES, AVHRR, MODIS, and VIIRS.[6,7,9]
Monitoring and Analysis Method: Product inspection, similar to that used in Beta and Provisional but with significant insight from users.[1,2,5]

A.3.2 Event Name: ABI-CONUS_CMI02

Same as for ABI-FD_CMI06 except for:
GOES-R Data Type(s): 5 min CONUS.[1,3]

A.3.3 Event Name: ABI-MESO_CMI02

Same as for ABI-FD_CMI06 except for:
GOES-R Data Type(s): 30 second mesoscale.[1,3]

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

B.1 Data Set #1: Name: ABI-L2-CMIP.[3]
Storage Location: SSEC Data Center.[9]
Point of Contact: Jerald Robaidek.[9]
Access Process: Product Distribution and Access (PDA) or STAR.[4,9]
Spatial Coverage: All modes: scan types - FD, CONUS, and mesoscale.[1,3]
Temporal Coverage: All modes, 15 min for FD, 5 min for CONUS, 30 second for mesoscale.[1,3]
Contingency: None, this is the Imagery products 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.[4]

B.2 Data Set #2: Name: ABI-L2-MCMIP[3]
Storage Location: SSEC Data Center.[9]
Point of Contact: Jerald Robaidek.[9]
Access Process: PDA or STAR.[4,9]
Spatial Coverage: All modes: scan types - FD, CONUS, and mesoscale.[1,3]
Temporal Coverage: All modes, 15 min for FD and CONUS, 5 min for mesoscale.[1,3]
Contingency: None, this is the Imagery products the team must validate, there is no validation without the core product.
Special Considerations: This is the GOES-R multi-spectral Imagery product, i.e., all bands are available at the same resolution (2 km).[1,4,7]

B.3 Data Set #3: Name: ABI-L1b-RAD (via GRB)
Storage Location: SSEC Data Center.[9]
Point of Contact: Jerald Robaidek.[9]
Access Process: Direct readout – GRB.[9]
Start Time: Immediately following Beta.[1]
Spatial Coverage: All modes: scan types - FD, CONUS, and mesoscale.[1,5,7]
Temporal Coverage: All modes, 15 min for FD, 5 min for CONUS, 30 second for mesoscale.[1,3]
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.[9]
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[1]
Storage Location: Science Investigator-led Processing System (SIPS).[9]
Point of Contact: N/A (SIPS is co-located with the Imagery team).[9]
Access Process: SIPS.[9]
Start Time: Immediately following Beta.[1]
Spatial Coverage: GOES coverage area that is collocated with the MODIS sensor.[5,7]
Temporal Coverage: All Imagery under Mode 3 or 4.[1,3]
Contingency: Use other collocated Imagery from data sets 5 and 6.[1,7]
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 above.

B.5 Data Set #5: Name: VIIRS Sensor Data Records (SDR)[1]
Storage Location: Science Investigator-led Processing System (SIPS).[9]
Point of Contact: N/A (SIPS is co-located with the Imagery team).[9]

Access Process: SIPS.[9]
Start Time: Immediately following Beta.[1]
Spatial Coverage: GOES coverage area that is collocated with the VIIRS sensor.[5,7]
Temporal Coverage: All Imagery under Mode 3 or 4.[1,3]
Contingency: Use other collocated Imagery from data sets 4 and 6.[1,7]
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 above. VIIRS SDRs may also be obtained from CLASS.[10]

B.6 Data Set #6: Name: GOES L1b[1]
Storage Location: Science Investigator-led Processing System (SIPS).[9]
Point of Contact: N/A (SIPS is co-located with the Imagery team).[9]
Access Process: SIPS.[9]
Start Time: Immediately following Beta.[1]
Spatial Coverage: GOES coverage area that is collocated with the VIIRS sensor.[5,7]
Temporal Coverage: All Imagery under Mode 3 or 4.[1,3]
Contingency: Use other collocated Imagery from data sets 4 and 5.[1,7]
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 above.

B.7 Data Set #7: Field Campaign Data[8]
Source: TBD (in development).
POC: Francis Padula
Access Process: TBD (in development)
Frequency of Transmission: N/A, any field campaign is a finite event.[1,3]
Contingency If Not Available: Validation of the Imagery is not strongly dependent on a field campaign, other sources of truth are more critical. It is therefore not a player in establishing the completion of any of the phases of validation for Imagery.[1,6,7,9]

C. Appendix C: Tools

C.1 Tool #1: Man-computer Interactive Data Access System version X (McIDAS – X).[1,5,6,7,9]
Location: Cooperative Institute for Meteorological Satellite Studies (CIMSS).[6,7]
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.[6,7]
Developer: SSEC McIDAS Programmers[9]
Development Schedule and Handover Plan: Tool is ready for cal/val use with GOES-R, though certain diagnostic data has yet to be tested.[9]
Data Dependencies: GOES-R.[6,7]
Testing Accomplished or Planned: Testing has been accomplished with both surrogate and simulated GOES-R Imagery, some minor additional testing remains regarding use of diagnostics, this is planned during the DOEs.[6,7,9,11]
POC: Becky Schaffer, McIDAS User Services.[9]

C.2 Tool #2: Man-computer Interactive Data Access System version V (McIDAS – V).[1,5,6,7,9]
Location: Cooperative Institute for Meteorological Satellite Studies (CIMSS).[6,7]
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.[6,7]
Developer: SSEC McIDAS Programmers.[9]
Development Schedule and Handover Plan: Tool is ready for cal/val use with GOES-R.[9]
Data Dependencies: GOES-R.[6,7]
Testing Accomplished or Planned: Testing has been accomplished with both surrogate and simulated GOES-R Imagery, though certain diagnostic data has yet to be tested; this is planned during the DOEs.[6,7,9,11]
POC: Becky Schaffer, McIDAS User Services.[9]

C.3 Tool #3: GLANCE[1,6,7]
Location: CIMSS.[6,7]
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.[9]
Developer: CIMSS in collaboration with the Algorithm Integration Team (AIT).[9]
Development Schedule and Handover Plan: CIMSS has completed development and it has been delivered to the AIT and Imagery team.[9]
Data Dependencies: GOES-R (Beta and Provisional), GOES, VIIRS, MODIS, and AVHRR (Provisional only).[9]
Testing Accomplished or Planned: AIT has completed its testing activities.[9]
POC: AIT.[9]

C.4 Tool #4: Tool for creating GOES-R Imagery from L1b obtained via the GRB (necessary for Provisional).[6,7,9]
Location: CIMSS.[6,7,9]

Description: This tool allows the Imagery cal/val team to recreate GOES-R Imagery from radiances retrieved through a direct readout antenna.[9]
Development Schedule and Handover Plan: Tool has finished development.[9]
Data Dependencies: GOES-R L1b through the GRB.[9]
Testing Accomplished or Planned: Testing has been accomplished with simulated radiances.[9]
POC: Kaba Bah.[9]

D. Appendix D: Acronyms

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
CLAVR-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
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

Acronym	Definition
LZSS	Level Zero Storage Solution
McIDAS	Man-computer Interactive Data Access System
MODIS	Moderate Resolution Imaging Spectroradiometer
MSFC	Marshall Space Flight Center
MUG	McIDAS User's Group
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
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
RIMP	Readiness, Implementation and Management Plan
SDR	Sensor Data Records
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