



Geostationary Operational Environmental Satellite (GOES) – R Series

ABI L2+ Rainfall Rate / Quantitative Precipitation Estimate (QPE) Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)

**ABI L2+ Rainfall Rate / Quantitative Precipitation Estimate (QPE)
Beta, Provisional and Full Validation
Readiness, Implementation and Management Plan (RIMP)**

Submitted by:

Signatures can be viewed in the CMO file

09/26/2016

Matthew Seybold
GOES- R Product Readiness and Operations Manager

Concurred by:

Signatures can be viewed in the CMO file

10/20/2016

Jaime Daniels
GOES-R Algorithm Working Group Lead

Date

Signatures can be viewed in the CMO file

11/02/2016

Edward Grigsby
GOES-R Program Systems Engineering Lead

Date

Signatures can be viewed in the CMO file

11/15/2016

Raymond Pages
GOES-R Ground Chief Project Engineer

Date

Approved by:

Signatures can be viewed in the CMO file

12/19/2016

James Valenti
GOES-R Ground Segment Project Manager

Date

Change Record

DOCUMENT TITLE: ABI L2+ Rainfall Rate / Quantitative Precipitation Estimate (QPE) Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)				
VERSION	DATE	CCR #	PAGES AFFECTED	DESCRIPTION
1.0	09/02/2016	03171	All	Initial

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

- **Working copy or Draft:** a document not yet finalized or ready for distribution; sometimes called a draft. Use 0.1A, 0.1B, etc. for unpublished documents.
- **Final:** the first definitive edition of the document. The final is always identified as Version 1.0.
- **Revision:** an edition with minor changes from the previous edition, defined as changes affecting less than one-third of the pages in the document. The version numbers for revisions 1.1 through 1.xx, 2.1 through 2.xx, and so forth. A revision in draft, i.e. before being re-baselined, should be numbered as 1.1A, 1.1B, etc.
- **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).

Table of Contents

Preface.....	1
1. Rainfall Rate / Quantitative Precipitation Estimation Validation Overview	4
2. Schedule of Events.....	6
3. Roles and Responsibilities	8
4. Tools	9
5. Analysis Methods.....	10
6. Output Artifacts	11
7. Pre-launch	13
8. References.....	14
A. Appendix A: Validation Events.....	15
B. Appendix B: GOES-R and Validation Reference Data	17
C. Appendix C: Tools.....	18
D. Appendix D: Acronyms	19

Table of Figures and Tables

Figure 1. GOES-R product maturity levels.....	2
Figure 2. Delineation of accountability between GOES-R and STAR.....	3
Table 1. QPE product cadences.	4
Figure 3. Schedule of events.....	7

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.

<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 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.
<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.

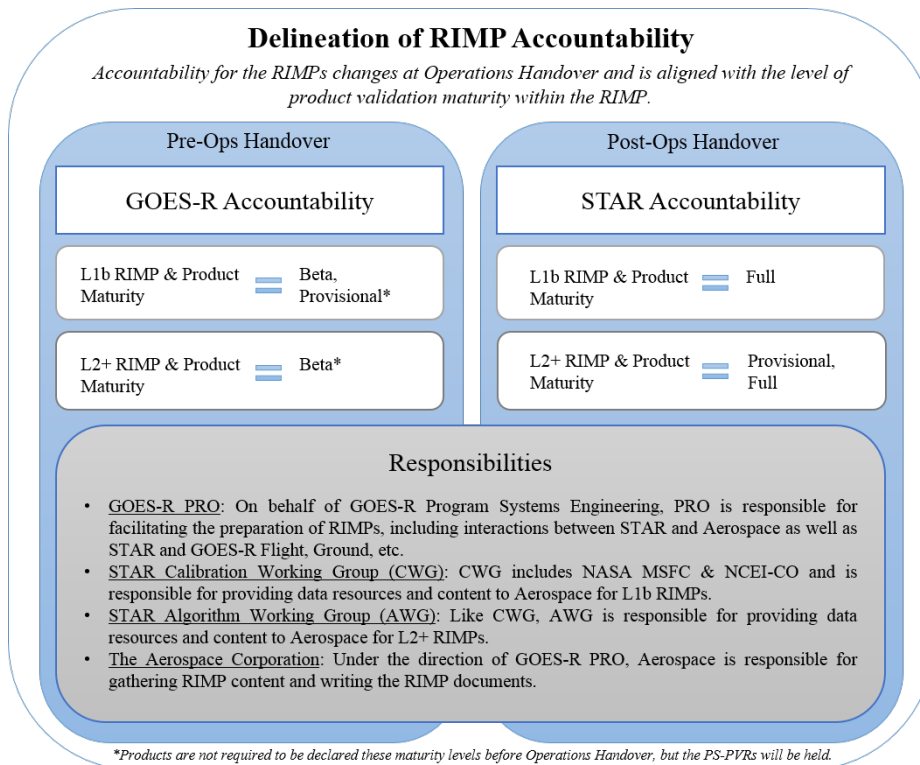


Figure 2. Delineation of accountability between GOES-R and STAR.

1. Rainfall Rate / Quantitative Precipitation Estimation Validation Overview

This RIMP covers all validation stages of the GOES-R Advanced Baseline Imager (ABI) Rainfall Rate/Quantitative Precipitation Estimation (QPE) L2 Product. There are three stages in the validation process: Beta, Provisional, and Full. Each stage is characterized by PLPTs, which guide the overall validation process. This RIMP includes a summary of the methods and tools employed to prove Rainfall Rate/QPE has met a given validation stage. Appendices are included that present more detail on each test method and detail on the different data sets employed in the validation of the Rainfall Rate/Quantitative Precipitation Estimation (QPE) product.

The Rainfall Rate/QPE PLPT validation plan has five (5) PLPT events defined.^{1,2} Three (3) of the events with IDs ABI-FD_QPE01, ABI-FD_QPE02, ABI-FD_QPE03 are to attain Beta maturity. PLPT event with ID ABI-FD_QPE04 is for Provisional maturity, and event ABI-FD_QPE05 is for Full maturity. The Mission Requirements Document (MRD) specifications for this product are to meet an accuracy of 6 mm/hr at 10 mm/hr rate and precision of 9 mm/hr at 10 mm/hr rate.³ The specifications are looser for higher rates; i.e., the accuracy and precision values are expected to be higher than the spec values for higher rain rates. The F&PS specifications are the same as MRD.⁴ PLPT events that support the Beta maturity are listed below, with details in Appendix A.1.

- **ABI-FD_QPE01:** to verify that product is generated every 15 min for every Full Disk (FD), for ABI Mode 3.
- **ABI-FD_QPE02:** to verify that product is generated every 15 min for every FD, for ABI Mode 4.
- **ABI-FD_QPE03:** to assess accuracy and precision of product.

The primary validation data sets are ground-based radar measurements (with gauges used for bias correction), rainfall rate of the Global Precipitation Measurement (GPM) and ground data. In addition to computing accuracy and precision, volume bias, correlation, threshold-dependent Probability of Detection (POD), False Alarm Ratio (FAR) area bias, and Heidke Skill Score (HSS) will also be calculated.² All the Beta maturity validation shall use the same tool suite, including colocation, statistical analysis, and visualization software,^{1,8} which is nearly done. Validation of the tool suite against Q3 and GPM DPR is still on going.

The following Table identifies the frequency of each scan type for Modes 3 and 4. The table includes the required cadence for FSC product defined by both the GOES-R Functional and Performance Specification (F&PS) and the Product User’s Guide (PUG). F&PS and PUG cadences are matched. The frequencies shown in the QPE – F&PS row (4th row) will be used by the product for verification.

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

Mode	Mode 3			Mode 4		
	FD	CONUS	Mesoscale	FD	CONUS	Mesoscale
Scan Freq	15 min	5 min	30 sec	5 min	5 min*	N/A
QPE – F&PS	15 min	N/A	N/A	15 min	N/A	N/A
QPE – PUG	15 min	N/A	N/A	15 min	N/A	N/A

Table 1. QPE product cadences.

PLPT event that support the Provisional maturity is listed below, with details in Appendix A.2.

- **ABI-FD_QPE04:** to assess accuracy and precision of product.

Provisional maturity validation effort is to quantitatively assess performance of the product against product accuracy and precision requirements and to establish that the product is ready for operational use (user decision). The primary validation data sets and tools for Provisional maturity are expected to be the same as for Beta maturity.

PLPT event that support Full maturity is listed below, with details in Appendix A.3.

- **ABI-FD_QPE05:** to assess accuracy and precision of product.

The primary validation data sets and tools for Full maturity are expected to be the same. The Full maturity validation effort is to quantitatively assess performance of the product against accuracy and precision requirements over a longer time period that represents seasonal changes and different conditions.

Details of validation processes and procedures, monitoring and analysis methods, tools, and expected output artifacts are described in the following sections. The details of each test are contained in Appendix A and of each reference data set are in Appendix B.

2. Schedule of Events

The Rainfall Rate/QPE product Beta maturity validation effort can be divided into two stages. The first stage, including 2 PLPTs, is to verify that when the sensor is in Mode 3 and Mode 4, the FD product is generated every 15 min, and is to fall within the expected measurement ranges. The first stage will take a week (or less). The second stage (1 test) is to quantitatively assess performance of the product with limited set of data identify Issues with the product, document performance and issues in the Beta report. The second stage will take roughly 5 weeks. The total Beta maturity testing time is planned for 6 weeks. The latest date to start Beta testing is L+155 days, but can begin as soon as the ABI L1b and Cloud and Moisture Imagery (CMI) reach Beta (L+87 days).

The Rainfall Rate/QPE product Provisional maturity validation effort is to quantitatively assess performance of the product against product accuracy and precision requirements through analysis of a large, but still limited, number of independent measurements or field campaign data. The total Provisional maturity validation time is planned for 6 months, starting from the end of the Beta maturity.

The Rainfall Rate/QPE product Full maturity validation effort is to quantitatively assess performance of the product against product accuracy and precision requirements through analysis of a large (spatially and seasonally representative) number of independent measurements or field campaign data. The total Full maturity validation time is planned for 9 months, starting from the end of the Provisional maturity.

Figure 3 shows the GOES-R validation schedule. System Performance Operation Test (SPOT) begins 44 days after launch when ABI L1b and the L2 CMI Key Performance Beta evaluation begins and should be declared Beta maturity by L+87 days. One day later, the GOES Rebroadcast (GRB) will be populated with that data. The L2 products must reach Beta maturity by handover at L+197 days, the same time that ABI L1b and CMI 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 L2 products to reach Full maturity, 15 months after handover.

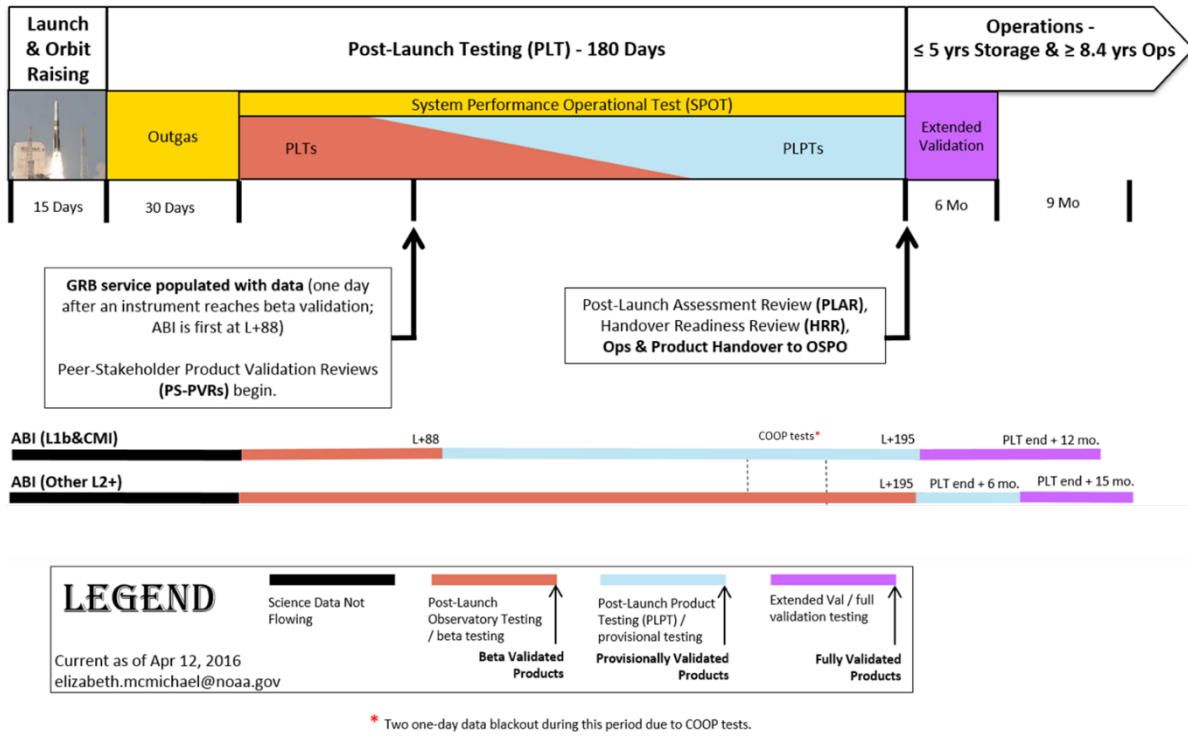


Figure 3. Schedule of events.

3. Roles and Responsibilities

3.1 Primary Point of Contact

The primary point of contact (POC) for leading the QPE validation effort is Bob Kuligowski.

3.2 GOES-R Point of Contact

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

3.3 Test Analyst/Engineer

Yaping Li is the primary test analyst. Yan Hao is the backup analyst.

3.4 GOES-R Feedback

Formal feedback to the GOES-R Program regarding the QPE validation will be provided by Jaime Daniels.

3.5 Level of Effort

The validation effort will amount to 50% of Bob Kuligowski's time plus 1.75 contractor FTE (1.0 FTE for Yaping Li and 0.75 FTE for Yan Hao) to monitor and evaluate the performance of the real-time validation tools and also to conduct deep-dive analysis of instances where the real-time validation indicates significant, systematic differences between the QPE rain rates and the ground validation data sets. This deep-dive effort will also include identifying, developing, and testing algorithm modifications to address any systematic issue that are discovered.

4. Tools

The same suite of tools, colocation tools, statistical analysis tools, and visualization tools, shall be used for all the PLPT events, for both routine validation and deep dive.^{5,6,7} In general, tools were developed in house with team effort and shared among the team members with reasonable in-code documentation and readme instructions. A list of detailed functions/subroutines is given in [8] (spreadsheet titled “Hydrology Team, Rainfall Rate/QPE”). Tools and processes related with reference data sets (except for those related with GPM data and GPM field campaign measurements) have been tested. Tools with GPM and GPM field-campaign data (new mission) were finished by the end of June 2016. Tools and processes specific for GOES-R are planned to test with DOE-3 and DOE-4 data when the data sets are available. A detailed description of the tools used for the QPE validation PLPTs can be found in Appendix C.

5. Analysis Methods

The rainfall rate algorithm identifies rainfall pixels from L1b data and retrieves the rate of rainfall for those pixels.² The retrieved rainfall areas and rainfall rates are calibrated against microwave rainfall rate data.

5.1 Calibration against Microwave Rainfall Rate

The GOES-R Rainfall Rate/QPE is calibrated with microwave rainfall rate data. Microwave data is updated whenever new microwave products become available in order to allow the algorithm to adapt to changes in meteorological regimes.^{2,6}

5.2 Comparisons with Ground-based Measurements

Real time comparisons with data from Hourly Stage IV/ Multisensor Precipitation Estimator (MPE) and gauges over CONUS.⁷ Comparison with pre-launch exercises have been performed. Comparison with instantaneous Multi-Radar Multi-Sensor (MRMS) 1 km radar-only rain rates and QC info on 0.01° lat/lon grid.

5.3 Comparisons with Satellite-derived Data

Comparisons with the precipitation radar rainfall rates from GPM (launched 2014). The data is available twice a day from NASA at (<http://pmm.nasa.gov/node/>).

5.4 Field Campaign Measurements

Appropriate ground validation radar, gauge, and disdrometer data from GPM will be used as data availability permits, specifically at the Melbourne, FL and Houston, TX sites. It is confirmed that the data is available to download.

5.5 Comparison with Model Data

Not considered for this product.

5.6 Deep-Dive Validation

Deep-dive validation is planned. Availability of GOES-R L2 diagnostic data is critical for this task.

6. Output Artifacts

The MRD specifications for this product are to meet accuracy of 6 mm/hr at 10 mm/hr rate with higher values at higher rates and precision of 9 mm/hr at 10 mm/hr rate with higher values at higher rates.³ The performance of this product will depend on upstream data quality, such as brightness temperature, and cloud/clear-sky masks. Uncertainties from upstream products will be filtered and populated in the quality flags of this product.

6.1 Beta Maturity Artifacts

Beta maturity is to quantitatively assess performance of the product with limited set of data and identify issues, identify issues with the product and document performance and issues in the Beta report. The Beta maturity success criteria are not dependent on the product meeting any performance requirements, and the pass/fail will not be dependent on user satisfaction.

The first two PLPTs are to inspect that the product is generated for FD for ABI Mode 3 and 4, and falls within expected measurement range. OSPO will take the lead to ensure that the product is generated at the required time intervals. Rainfall Rate/QPE cal/val team will take the lead to verify that the product falls within the expected measurement range (0 to 100 mm/hr). 24 hours of continuous data is required for this process.

The third test is to assess the product performance for a very limited data set. Beta success criteria will follow the common language defined above (the first paragraph of Section 6).

At the completion of the Beta maturity validation, results shall be presented at Peer Stakeholder - Product Validation Reviews (PS-PVRs). The presentation shall detail the data sets and processes used and the results in terms of product accuracy and precision.

6.1.1 These tests of priority 1 all must pass in order to achieve Beta Maturity

- ABI-FD_QPE01
- ABI-FD_QPE02
- ABI-FD_QPE03

6.1.2 The QPE Beta maturity validation effort does not include any tests of priority 2.

6.2 Provisional Maturity Artifacts

The Rainfall Rate/QPE product Provisional maturity validation effort is to quantitatively assess performance of the product against product accuracy and precision requirements through analysis of a large, but still limited, number of independent measurements or field campaign data. The Provisional maturity pass/fail criteria are:

- Product performance has been demonstrated and compared against accuracy and precision requirements through analysis of a large, but still limited, number of independent measurements or field campaign data.
- Documentation of product performance, identified product performance anomalies, including recommended remediation strategies. Accuracy and precision do not have to meet requirements to attain Provisional status, however, if they do not do so, the reasons need be documented.
- Documentation of impacts from challenges with upstream dependencies.
- Documentation of feedback from the primary user (NWS), if any.
- Product is ready for potential operational use (user decision) and for use in scientific publications.

At the completion of the Provisional maturity validation, results will be presented at PS-PVRs. The presentation shall detail the above list.

6.2.1 These tests of priority 1 all must pass in order to achieve Provisional Maturity

- ABI-FD_QPE04

6.2.2 The QPE Provisional maturity validation effort does not include any tests of priority 2.

6.3 Full Maturity Artifacts

The Rainfall Rate/QPE product Full maturity validation effort is to quantitatively assess performance of the product against product accuracy and precision requirements through analysis of a large (global and seasonally representative) number of independent measurements or field campaign data. The Full maturity pass/fail criteria are:

- Product performance has been demonstrated and compared against accuracy and precision requirements through over a large and wide range of representative conditions, (i.e., covering the entire region within the Product Extent Qualifier, seasonally representative).
- Documentation of product performance, identified product performance anomalies, including recommended remediation strategies. If the product accuracy and precision requirements cannot be met due to non-algorithm error at certain regions or under certain conditions, the reasons need to be documented.
- Documentation of impacts from challenges with upstream dependencies.
- Product is ready for operational use and for use in scientific publications.
- At the completion of the Full maturity validation, results will be presented at PS-PVRs. The presentation shall detail the above list.

6.3.1 These tests of priority 1 all must pass to achieve Full maturity:

- ABI-FD_QPE05

6.3.2 The QPE Full maturity validation effort does not include any tests of priority 2.

6.4 Key Artifacts

Key artifacts for the QPE validation effort are power point presentations to report validation results.

6.5 More Output Artifacts

There are no additional output artifacts for the QPE validation.

6.6 Delivery Schedule

The delivery schedule of artifacts for the QPE validation is tied to the schedule for completing Beta, Provisional, and Full validation as given in section 2. Power point presentations will be ready in time for the PS-PVR.

7. Pre-launch

Pre-launch exercises have been performed to insure all the team members are prepared for PLPT events.^{1,2,6} Tools and processes related with reference data sets (except for those related with GPM data and GPM field campaign measurements) have been exercised. Tools with GPM and GPM field campaign data have been completed. Tools and processes specific for GOES-R are to be exercised with DOE-3 and DOE-4 data, which included diagnostics. Therefore, all the tools and processes will be exercised pre-launch.⁹ While DOE data is exact in format, the data values might be unrealistic, so anticipate the need for additional testing on orbit with real data.

It is confirmed that all tools and processes are developed by team efforts with reasonable code documentation and readme instructions. Therefore, all the team members, including back up, are able to access and operate the tool set.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] PLPT_VE_List_L2_v1_0_20141022.xlsx.
- [2] GOES-R Series Calibration/Validation Plan Volume 2: Level 2+ Product Validation (410-R-PLN-0194)
- [3] MRD_V3_17.pdf.
- [4] GOES-R_GS_FPS.pdf.
- [5] 03_Kuligowski_2ndAWGvalidationWorkshop_Kuligowski: QPE/Rainfall Rate.
- [6] GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document for Rainfall Rate (QPE).
- [7] Product Name_Validation_Table_RainfallRateQPE_v3_rico.docx.
- [8] L2 Product Validation Tools_05-12-2015.xlsx.
- [9] Rainfall Rate RIMP Telecom Discussion 2015 06 09, Frank Sun, Bob Kuligowski, Wayne Mackenzie, Jaime Daniels.

A. Appendix A: Validation Events

A.1 PLPT Events that Support Beta Maturity

A.1.1 Name: ABI-FD_QPE01

Objective: Verify that product is generated every 15 min of the day for every FD.

Start Time: TBD.

Duration: 1 week.

ABI Mode: Mode 3.

GOES-R Data Type(s): FD 15 min.

Beta Success Criteria: Product generated and falls within expected measurement range, 24 hours data to go through.

PLPT Lead: Bob Kuligowski.

PLPT Analyst: Yaping Li.

Procedure References: GOES-R Series Calibration/Validation Plan Volume 2: Level 2+ Product Validation.²

Comparison/Reference Data: None.

A.1.2 Name: ABI-FD_QPE02

Same as ABI-FD_QPE01 except for:

Start Time: TBD.

Duration: 1 week.

ABI Mode: Mode 4.

Beta Success Criteria: Product generated and falls within expected measurement range, 24 hours of data to go through.

A.1.3 Name: ABI-FD_QPE03

Objective: Assess accuracy and precision of product.

Description: Compare to reference/ground truth data. Reference: Cal/Val Plan (P410-R-PLN-0194) Section 3.6.

Justification: Provides an early assessment of product performance. Focuses on assessing and characterizing product accuracy and precision that needs to be conveyed to the user community.

Start Time: TBD.

Duration: 5 weeks.

ABI Mode: Mode 3.

GOES-R Data Type(s): FD 15 min.

Beta Success Criteria: Quantitatively assess performance with limited set of data.⁹

PLPT Lead: Bob Kuligowski.

PLPT Analyst: Yaping Li.

Procedure References: GOES-R Series Calibration/Validation Plan Volume 2: Level 2+ Product Validation (410-R-PLN-0194) Section 3.6.²

Comparison/Reference Data: Ground based real time data from the MPE (Data Set #1), Multi-Radar Multi-Satellite (MRMS) (Data Set #2), and gauges over CONUS (Data Set #3), data from the GPM (Data Set #4).^{2,5}

A.2 PLPT Events that Support Provisional Maturity

A.2.1 Name: ABI-FD_QPE04

Objective: Assess accuracy and precision of product.

Description: Compare to reference/ground truth data. Reference: Cal/Val Plan (P410-R-PLN-0194) Section 3.6.

Justification: Provides an early assessment of product performance. Focuses on assessing and characterizing product accuracy and precision that needs to be conveyed to the user community.¹

Start Time: TBD.

Duration: Approximately 24 weeks.

ABI Mode: Mode 3.

GOES-R Data Type(s): FD 15 min.

Provisional Success Criteria: Product meets MRD specifications for a very limited (i.e., not seasonally representative) number of independent measurements. Product is ready for operational use (user decision).

PLPT Lead: Bob Kuligowski.

PLPT Analyst: Yaping Li.

Procedure References: Cal/Val Plan (P410-R-PLN-0194) Section 3.6.²

Comparison/Reference Data: Ground based real time data from the MPE (Data Set #1), MRMS (Data Set #2), and gauges over CONUS (Data Set #3), data from the GPM (Data Set #4).^{2,5}

A.3 PLPT Events that Support Full Maturity

A.3.1 Name: ABI-FD_QPE05

Objective: Assess accuracy and precision of product.

Description: Compare to reference/ground truth data. Cal/Val Plan (P410-R-PLN-0194) Section 3.6.

Justification: Provides an early assessment of product performance. Focuses on assessing and characterizing product accuracy and precision that needs to be conveyed to the user community.¹

Start Time: TBD.

Duration: end of the Full Validation stage defined by schedule chart

ABI Mode: Mode 3.

GOES-R Data Type(s): FD 15 min.

Full Success Criteria: Product meets F&PS specifications for a large and wide range of representative conditions over a period of at least a year. Product is ready for operational use and for use in scientific publications

PLPT Lead: Bob Kuligowski.

PLPT Analyst: Yaping Li.

Procedure References: GOES-R Series Calibration/Validation Plan Volume 2: Level 2+ Product Validation (410-R-PLN-0194), Section 3.6.²

Comparison/Reference Data: Ground based real time data from the MPE (Data Set #1), MRMS (Data Set #2), and gauges over CONUS (Data Set #3), data from the GPM (Data Set #4).^{2,5}

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

B.1 Data Set #1: Ground based real time MPE data and gauges data over CONUS

Description: Multisensor Precipitation Estimator.

Likelihood of Availability: High.

Consequence If Not Available: High.

Storage Location: NCEP (<http://www.emc.ncep.noaa.gov/mmb/ylin/pcpanl/stage4/>).

Access Process: Download.

POC: Ying Lin (Ying.Lin@noaa.gov) of NCEP/EMC

Spatial Coverage: CONUS.

Temporal Coverage: Hourly.

B.2 Data Set #2: MRMS 1 km radar-only rain rates and QC info on 0.01° lat/lon grid

Description: Instantaneous MRMS 1-km radar-only rain rates and QC info on 0.01° lat/lon grid.

Likelihood of Availability: High.

Consequence If Not Available: Medium.

Storage Location: NCEP Central Operations (NCO; IP address is not public).

Access Process: Download.

POC: Help desk

Spatial Coverage: 1 km on 0.01° lat/lon grid.

Temporal Coverage: 15 m.

B.3 Data Set #3: Gauges network over CONUS

Description: NWS/CPC cooperative gauge network (COOP) gauges

Likelihood of Availability: High.

Consequence If Not Available: Medium.

Storage Location: ftp.cpc.ncep.noaa.gov/GIS/JAWF/precip/ in ASCII format.

Access Process: Download.

POC: Help desk

Spatial Coverage: CONUS

Temporal Coverage: daily.

B.4 Data Set #4: GPM data

Description: GPM precipitation radar rainfall rates (continuous).

Likelihood of Availability: High.

Consequence If Not Available: Medium.

Storage Location: NASA (<http://pmm.nasa.gov/node/>).

Access Process: Download.

POC: Help desk

Spatial Coverage: GPM covers the whole globe from 60 S to 60 N but it's in an inclined orbit so it's not continuous coverage. Swath width is 120 km

Temporal Coverage: Approximately twice/day.

C. Appendix C: Tools

C.1 Tool #1: Colocation tool

Location: In house.

Description: Retrieve and merge satellite and reference data, aggregate different data on the ABI native grid. Tools were developed by team effort with reasonable in-code documentation and readme instructions⁸.

Classification: Routine and deep dive.

Documentation: In-code documentation and readme instructions.

Developer: Team effort (Bob Kuligowski, Yaping Li, and Yan Hao).

Development Schedule: Fully functional, June 2016 (ready for launch).

Testing Accomplished or Planned: See above (Section 4).

POC: Bob Kuligowski.

C.2 Tool #2: Statistical analysis tool Suite

Location: In house.

Description: Compute basic performance statistics for routine analysis and deep dive. Tools were developed by team effort with reasonable in-code documentation and readme instructions⁸.

Classification: Routine and deep dive.

Documentation: In-code documentation and readme instructions.

Developer: Team effort (Bob Kuligowski, Yaping Li, and Yan Hao).

Development Schedule: Fully functional, June 2016 (ready for launch).

Testing Accomplished or Planned: See above (Section 4).

POC: Bob Kuligowski.

C.3 Tool #3: Visualization tool

Location: In house.

Description: Create plots and images. Tools were developed by team effort with reasonable in-code documentation and readme instructions⁸.

Classification: Routine and deep dive.

Documentation: In-code documentation and readme instructions.

Developer: Team effort (Bob Kuligowski, Yaping Li, and Yan Hao).

Development Schedule: Fully functional, June 2016 (ready for launch).

Testing Accomplished or Planned: See above (Section 4).

POC: Bob Kuligowski.

D. Appendix D: Acronyms

Acronym	Definition
ABI	Advanced Baseline Imager
AWG	Algorithm Working Group
Cal/Val	Calibration and Validation
CCR	Configuration Change Request
CMI	Cloud and Moisture Imagery
CONUS	Continental United States
CWG	Calibration Working Group
DOE	Data Operations Exercise
F&PS	Functional and Performance Specification
FAR	False Alarm Ratio
FD	Full Disk
GOES	Geostationary Operational Environmental Satellite
GOES-R	GOES R-Series
GORWG	GOES-R Series Operational Requirements Working Group
GPM	Global Precipitation Measurement
GRB	GOES Rebroadcast
HSS	Heidke Skill Score
L1b	Level 1b
L2	Level 2
MPE	Multisensor Precipitation Estimator
MRD	Mission Requirements Document
MRMS	Multi-Radar Multi-Satellite
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NCEI	National Centers for Environmental Information
NCEI-CO	NCEI - Colorado
NCEP	National Centers for Environmental Prediction
NCO	NCEP Central Operations
NLT	No Later Than
NWS	National Weather Service
OSPO	Office of Satellite and Product Operations
PLAR	Post-Launch Assessment Review
PLPT	Post-Launch Product Test
PLT	Post-Launch Test
POC	Point of Contact
POD	Probability of Detection
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
QPE	Quantitative Precipitation Estimation
RIMP	Readiness, Implementation and Management Plan
SPOT	System Performance Operational Test
STAR	Center for Satellite Applications and Research
TBD	To Be Determined
VCRM	Verification Cross Reference Matrix