Geostationary Operational Environmental Satellite (GOES) – R Series

ABI L2+ Fire Hot Spot Characterization (FHS) Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)

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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.

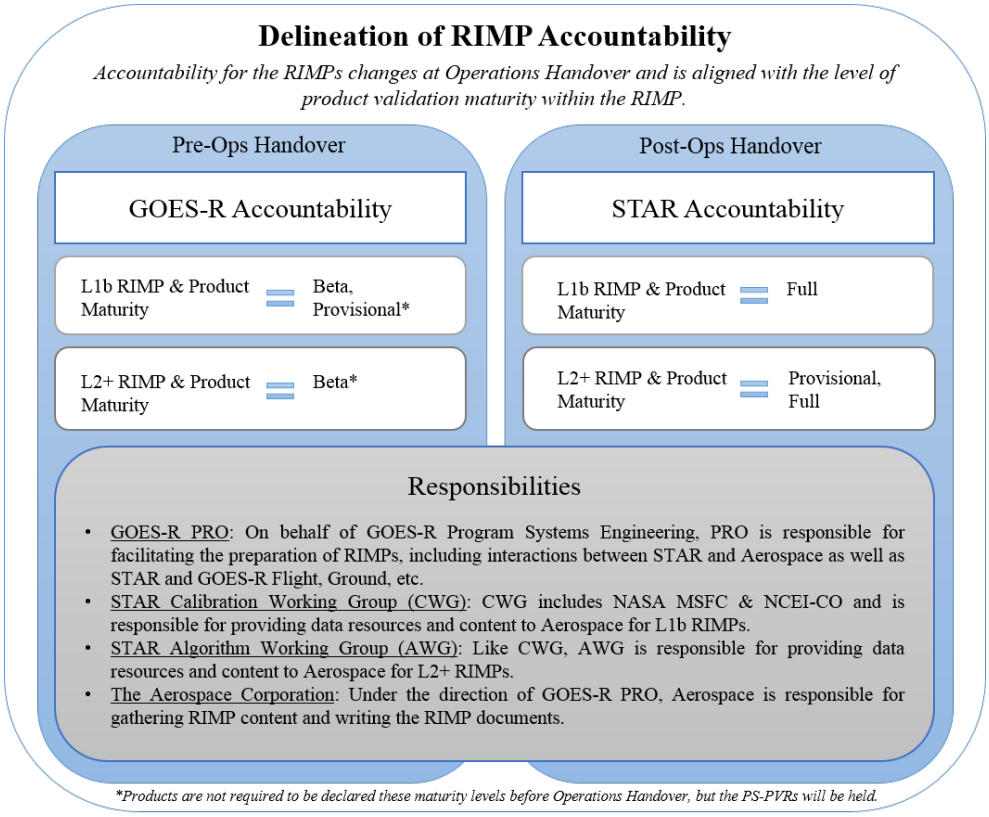

Figure 2. Delineation of accountability between GOES-R and STAR.

1. Fire Hot Spot Characterization Validation Overview

This Readiness, Implementation, and Management Plan (RIMP) covers validation stages of the GOES-R Advanced Baseline Imager (ABI) Fire Hot Spot Characterization (FHS) Level 2 product. 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 prove that FHS has met a given validation stage. Appendices present more detail on each PLPT and describe the different data sets employed in the validation of the FHS product.

The GOES-R ABI FHS product provides a fire mask indicating the location of active fires, saturated pixels, opaque cloud coverage, and processing block-out zones. Fire characteristics for this product are size, temperature and radiative power. The determination of whether or not a pixel represents a fire is the essence of fire detection. The final output also contains a fire confidence flag. Routine validation will assess overall product consistency with other operational fire products; deep-dive analyses conducted after Beta maturity will quantify performance metrics.

The fire requirements for GOES-R ABI are in terms of 3.9 µm band (Band 7) brightness temperatures as well as instantaneous fire size, temperature, and Fire Radiative Power (FRP). There is no direct assessment for sub-pixel fire temperature retrievals. Due to the nature of the algorithm, brightness temperatures calculated from fire size and temperatures should always be within the product accuracy and precision specifications. Users want detections to have as few false alarms as possible, while picking up as many fires as can reasonably be expected for the satellite. Therefore the performance metrics to be evaluated are fire location (assessed in terms of commission and omission error rates) and when quality reference data are available, sub-pixel fire size and fire radiative power retrieval accuracy.

Twelve PLPTs have been defined to attain Beta maturity.[1] The first ten events verify that: when the sensor is in Modes 3 and 4, the Full Disk (FD) and CONUS products are generated within the expected measurement ranges. These initial events are one week in duration, occur in parallel, and commence when the GOES-R ABI L1b data are declared Beta, whichever is sooner. The last two Beta PLPTs are 5 weeks each, occur in parallel, and will provide initial performance assessments of the FD and CONUS products in sensor Mode 3.

The two criteria for declaring Beta maturity are to: (1) provide a quantitative performance assessment with limited set of data; and (2) identify issues with product. The performance metric defines whether fire location (in terms of commission and omission errors) is comparable to other sources (GOES-E, GOES-W, VIIRS, and MODIS) at least 50% of the time.

Two PLPTs have been defined to attain Provisional maturity by quantifying performance for an expanded, though not seasonally representative, number of independent measurements. In addition to omission and commission error rates metrics, probability of fire detection as a function of sub-pixel fire characteristics will also be evaluated. The GOES-R Operations phase begins at the end of PLPT and marks the start of the two FHS Provisional PLPTs (FD and CONUS) which occur concurrently over 24 weeks. The Provisional maturity criteria are that performance demonstrated is sufficient for the user to determine that the product is ready for operational use and remediation strategies are in work for any performance issues identified.

Two PLPTs have been defined to attain Full maturity by further extending the conditions under which the FHS product performance are quantified to include a seasonally representative number of independent measurements. These two FHS Full maturity PLPTs (FD and CONUS) occur concurrently over a 36 week period. The criteria for success are that the user agrees that the demonstrated performance warrants declaring the product has achieved Full maturity, and sufficient remediation strategies are in work for any performance issues identified.

PLPT events that support Beta maturity are listed below; details are in Appendix A:

- **ABI-FD_FHS01:** verify that fire activity is detected in Mode 3 FD products generated every 15 min is in accordance with expected measurement range.
- **ABI-CONUS_FHS02:** verify that fire activity is detected in Mode 3 CONUS products generated every 5 min is in accordance with expected measurement range.
- **ABI-FD_FHS03:** verify that fire-free pixels in FD products are classified accordingly in Mode 3.
- **ABI-CONUS_FHS04:** verify that fire-free pixels in CONUS products are classified accordingly in Mode 3.
- **ABI-FD_FHS05:** verify that fire activity detected in Mode 4 FD products generated every 5 min is in accordance with expected measurement range.
- **ABI-CONUS_FHS06:** verify that fire activity detected in Mode 4 CONUS products generated every 5 min is in accordance with expected measurement range.
- **ABI-FD_FHS07:** verify that fire-free pixels in FD products are classified accordingly in Mode 4.
- **ABI-CONUS_FHS08:** verify that fire-free pixels in CONUS products are classified accordingly in Mode 4.
- **ABI-FD_FHS09:** initial assessment of FD product performance.
- **ABI-CONUS_FHS10:** initial assessment of CONUS product performance

PLPT events that support Provisional maturity are listed below; details are in Appendix A:

- **ABI-FD_FHS11:** assessment of FD product performance for an extended period that includes some but not all seasonal variability, to demonstrate operational readiness.
- **ABI-CONUS_FHS12:** assessment of CONUS product performance for an extended period that includes some but not all seasonal variability, to demonstrate operational readiness.

PLPT events that support Full maturity are listed below; details are in Appendix A:

- **ABI-FD_FHS13:** assessment of FD product performance for an extended period that includes seasonal variability.
- **ABI-CONUS_FHS14:** assessment of CONUS product performance for an extended period that includes seasonal variability.

Table 1 identifies the frequency of each scan type for Modes 3 and 4. It includes the required cadence of the FHS 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. All of the products, whether produced every 15 or 5 minutes will be used in generating the verification results.

**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

Scan Type	FD	CONUS	Meso	FD	CONUS	Meso
Scan Freq	15 min	5 min	30 sec	5 min	5 min*	N/A
FHS – F&PS Freq	15 min	5 min	N/A	15 min	5 min	N/A
FHS – PUG Freq	15 min	5 min	N/A	5 min	5 min	N/A
FHS Verification Freq	15 min	5 min	N/A	5 min	5 min	N/A

Table 1. FHS product and verification cadences.

The validation reference or truth data for Beta performance assessments include: VIIRS, MODIS, GOES Wildfire Automated Biomass Burning Algorithm (WFABBA), and Advanced Very High Resolution Radiometer (AVHRR). During the Provisional and Full maturity performance assessments, Landsat-class, in terms of spatial resolution, fire reference data will drive the deep-dive validation analyses. Those analyses may be complemented by field campaign data, if available. The details of validation reference data are provided in Appendix B.

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 these data 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 9 months period for L2 products to reach Full maturity 15 months after handover.

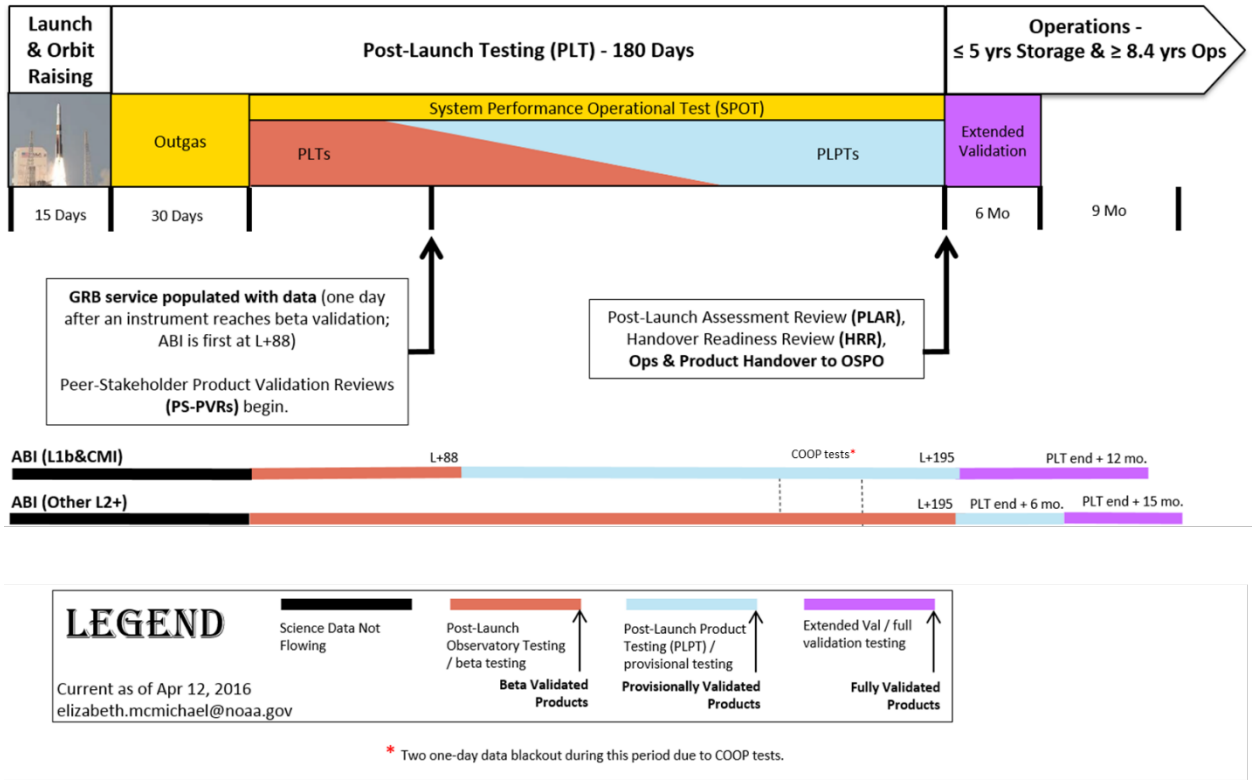

Figure 3. Schedule of validation events.

3. Roles and Responsibilities

3.1 Primary Point of Contact

The primary point of contact (POC) for leading the FHS validation effort is Yunyue (Bob) Yu.

3.2 GOES-R Point of Contact

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

3.3 Test Analyst/Engineer

Chris Schmidt (Cooperative Institute for Meteorological Satellite Studies (CIMSS)) is the primary test analyst.

3.4 GOES-R Feedback

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

3.5 Flight Point of Contact

Coordination with the Flight Project will occur through the L1b team. The POC for coordination with the L1b team is TBD.

3.6 Level of Effort

The Beta analysis is projected to require 0.09 FTE Level of Effort for each of the eight one-week concurrent PLPT Beta range check tests. This is a total of 28 hours (.09 x 8 tests x 40 hrs/wk) or 0.72 FTE level of effort the first week. The remaining two FHS PLPTs for the initial Beta performance assessment occur in parallel over the next five weeks and require 0.38 FTE each, which is (0.38 x 2) or 0.76 FTE level of effort during this five week period. The same level of effort will be sustained throughout the 24 week Provisional PLPTs and 36 weeks of Full analysis to expand the conditions under which the product is evaluated.

Chris Schmidt is developing the in-house tools which will require 0.3 FTE (15.6 person weeks). The target date for tool completion is July 2016. Chris Schmidt is also the FHS POC responsible for providing feedback to the L1 and L2 teams through regular coordination meetings that will take place between the L1b Calibration Working Group (CWG) and the L2 Algorithm Working Group (AWG) and to develop an algorithm change in accordance with the GOES-R Series Ground Segment Project Algorithm Change Management Plan, if such a change is determined to be critical to product maturity.[2]

4. Tools

Two tools will be used for the FHS PLPTs: the software used to perform routine functions such as generating simple statistics and overlaying fire products for visual comparison; and additional code to produce the reference fire data from higher spatial resolution Landsat-class data and co-locate GOES-R/ABI FHS and the reference fire data in support of deep-dive analyses. [3] These tools are described in more detail in Appendix C.

5. Analysis Methods

The validation objective is to establish performance in terms of the metrics listed below for the full range of required conditions[4]:

- Probabilities of fire detection as a function of sub-pixel fire characteristics. Sub-pixel fire characteristics are measured ideally in actual physical variables such as area or fractional area, and temperature; alternatively, as summary statistics of fire pixels from higher spatial resolution sensors. The difference in spatial resolution between sensors should optimally be equal to or greater than an order of magnitude.
- Omission error rates: fraction of cloud-free ABI pixels with confirmed fire activity exceeding pre-defined classification thresholds, not flagged as fire.
- Commission error rates: fraction of ABI fire pixels with no confirmed, with measurable fire activity.

The accuracy and precision of brightness temperatures derived from forward radiance calculations using fire size and temperature and the background temperature are governed by the tolerance thresholds of the iterative methods used to determine the fire characteristics. Possible fire pixels where such a convergence is not possible are not assigned fire characteristics, but may still be classified as fires. The threshold used in the FHS algorithm is reached when the forward radiance calculation is within 1.0e-20 radiance units (watts per meters squared per steradian per wavelength unit) of the observation or once 30 iterations using Newton's method have been calculated (a rare circumstance).

The Beta evaluation will primarily be concerned with whether the FHS algorithm is working by looking at overall product consistency based on comparison to primarily to GOES WFABBA, VIIRS, MODIS, and/or AVHRR. The five week analysis will produce very preliminary estimates of omission and commission error rates, while the Provisional and Full analyses will provide a comprehensive estimate of these metrics.

5.1 Routine Inspection

The Beta PLPT range checks will be accomplished through a qualitative comparison of the fire product to Band 7 using McIDAS and a GE based system. Visual inspection of other satellite fire data sources in addition to Band 7 will provide an indication that a fire was not occurring to satisfy the null tests.

5.2 Routine Comparison to Satellite Data

Routine Beta validation consists of co-locating ABI detected fires with those from current GOES and polar orbiting platforms (MODIS, VIIRS, and AVHRR). Geostationary and polar orbiting satellite sensor fire detections will be used in near real time. Perfect agreement is not expected due to system differences. Routine validation IDL scripts will perform temporal and spatial colocations, measuring the separation in those dimensions and reporting when matches between sources do and do not occur. These routine assessment will continue during the Provisional and Full assessment periods after handover.

5.3 Deep Dive Validation

Very limited deep-dive investigations might be conducted during Beta, though deep-dive analyses is primarily a method to be relied on during the Provisional and Full assessment periods. Reference validation data sets based on Landsat-8 daytime imagery will be sampled across FD and CONUS domain areas and co-located to coincident FHS data using automated scripts. Summary fire activity statistics will be calculated based on the number of Landsat-8 30 m reference fire pixels found within individual ABI effective pixel footprints, and used to estimate omission and commission error rates. Complementary field campaign data (e.g., specialized airborne fire mapping

instruments), when available, may be used to assess FHS fire pixel retrievals (i.e., fire area, fire radiative power).

6. Output Artifacts

Performance assessment and product issues will be documented at the conclusion of each maturity assessment phase.

6.1 Beta Maturity Artifacts

At the completion of the Beta phase a report will be generated detailing the methods used and the results of comparisons between GOES-R fire location (in terms of commission and omission errors) and that from other sources (GOES, VIIRS, and MODIS) available during the limited PLPT timeframe.

6.1.1 All Beta tests listed in Appendix A are priority 1 which means their success criteria must be met to reach Beta maturity.

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

6.2 Provisional Maturity Artifacts

At the conclusion of the Provisional stage, results will be presented at a Peer Stakeholder - Product Validation Review (PS-PVR) detailing the methods used and the FHS product performance in terms of probability of fire detection as a function of sub-pixel fire characteristics and omission and commission error rates over a large and wide range of conditions. Representative conditions will include the full range of biomes and surface types present within the FD, including but not limited to wildfires in boreal forest, rainforest, wooded mountains, grassy plains, and agricultural burning during the seasons present during the assessment period. Any product deficiencies discovered will be documented along with remediation strategies and challenges with upstream dependencies. User feedback will be critical in determining whether the omission and commission rates are acceptable, given the probability of detecting the fires of interest. The Provisional presentation will include a summary of user feedback received during the assessment period.

6.2.1 All Provisional tests listed in Appendix A are priority 1 – their success criteria must be met to reach Provisional maturity.

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

6.3 Full Maturity Artifacts

At the conclusion of the Full maturity stage, results will be documented in an updated presentation for a PS-PVR covering everything described above for the Provisional presentation, but covering a longer period of record that includes seasonal variations.

6.3.1 All Full tests listed in Appendix A are priority 1 – their criteria must be met to reach the Full validation stage.

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

6.4 Key Artifacts

The key artifact for the FHS validation effort is the statistical analysis of probability of fire detection as a function of sub-pixel fire characteristics and omission and commission error rates which will be covered in the Beta report and the Provisional and Validated presentations described above.

6.5 More Output Artifacts

There are no other artifacts besides those noted in sections 6.1 through 6.4.

6.6 Delivery Schedule

The delivery schedule of artifacts for the FHS validation coincides with the completion of the associated maturity stages as shown in the Section 2 schedule. All statistical analysis necessary to prove a given validation stage will completed in time for the appropriate PS-PVR.

7. Pre-launch

Basic testing of the validation tools was accomplished with simulated data during algorithm development. Remaining pre-launch tool development and testing for routine Beta readiness is described in Section 4.

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 Ground Segment Project Algorithm Change Management Plan, G416-R-ALGCMP-0285.
[3] L2 Product Validation Tools_05-12-2015.xlsx.
[4] CV Workshop charts: Application_Team_Validation_LST_v1.ppt.

A. Appendix A: Validation Events

A.1 PLPT Events that Support Beta Maturity

A.1.1 ABI-FD_FHS01: Range Test

Objective: Verify that fire activity detected in FD products generated every 15 min is in accordance with expected measurement range.
Start Time: Start of PLPT.
Duration: 1 week.
ABI Mode: Mode 3.
GOES-R Data Type(s): FD, Bands 2,7,14, and 15.
Beta Success Criteria: Products are generated when fires are present.
Dependencies: L1b data reaching Beta maturity in time for PLPT start.
PLPT Lead: Bob Yu.
PLPT Analyst: Chris Schmidt; FTE 0.09.
Validation Data: No truth data needed as test involves visual inspection of ABI Band 7.
Monitoring and Analysis Method: Inspection: qualitatively compare product to Band 7.

A.1.2 ABI-CONUS_FHS02: Range Test

Same as for ABI-FD_FHS01 except for:
Objective: Verify that fire activity detected in CONUS products generated every 5 min is in accordance with expected measurement range.
GOES-R Data Type(s): CONUS, Bands 2, 7, 14, and 15.

A.1.3 ABI-FD_FHS03: Null Test

Same as for ABI-FD_FHS01 except for:
Objective: Verify that fire-free pixels in FD products generated every 5 min are classified accordingly.
Beta Success Criteria: No more than 25% of the detected fires cannot be seen in the Band 7 and/or reference data.
Validation Data: Other satellite fire data sources provide an indication that a fire was not occurring, as well as visual inspection of Band 7. This type of analysis would be done in McIDAS and Google Earth (or GE based system, such as Space Science and Engineering Center (SSEC)'s Real Earth).
Monitoring and Analysis Method: Null test.

A.1.4 ABI-CONUS_FHS04: Null Test

Same as for ABI-FD_FHS03 except for:
Objective: Verify that fire-free pixels in CONUS products generated every 5 min are classified accordingly.
GOES-R Data Type(s): CONUS, Bands 2, 7, 14, and 15.

A.1.5 ABI-FD_FHS05: Range Test

Same as for ABI-FD_FHS01 except for:
Objective: Verify that fire-free pixels in FD products generated every 5 min are classified accordingly.
ABI Mode: Mode 4.

A.1.6 ABI-CONUS_FHS06: Range Test

Same as for ABI-FD_FHS05 except for:
Objective: Verify that fire activity is detected in CONUS products generated every 5 min in accordance with expected measurement range.
GOES-R Data Type(s): CONUS, Bands 2, 7, 14, and 15.

A.1.7 ABI-FD_FHS07: Null Test

Same as for ABI-FD_FHS03 except for:
ABI Mode: Mode 4.

A.1.8 ABI-CONUS_FHS08: Null Test

Same as for ABI-FD_FHS07 except for:
Objective: Verify that fire-free pixels in CONUS products generated every 5 min are classified accordingly.
GOES-R Data Type(s): CONUS, Bands 2, 7, 14, and 15.

A.1.9 ABI-FD_FHS09: FD FHS performance test

Same as for ABI-FD_FHS01 except for:
Objective: Determine the FD FHS algorithm is working through a preliminary assessment of probability of fire detection, as a function of sub-pixel characteristics and omission and commission error rates.
Duration: 5 weeks.
Beta Success Criteria: Probability of fire detection, as a function of sub-pixel characteristics and omission and commission error rates must be comparable to reference data at least 50% of the time.
PLPT Analyst: Chris Schmidt; 0.38 FTE.
Validation Data: GOES, VIIRS, MODIS, and AVHRR.
Monitoring and Analysis Method: Routine inspection and comparison to satellite data.
Notes: Due to the nature of the algorithm, brightness temperatures, calculated from fire size and temperatures, should always be within the product accuracy and precision specifications.

A.1.10 ABI-CONUS_FHS10: CONUS FHS performance test

Same as for ABI-FD_FHS09 except for:
Objective: Determine the CONUS FHS algorithm is working through a preliminary assessment of probability of fire detection, as a function of sub-pixel characteristics and omission and commission error rates.
GOES-R Data Type(s): CONUS, Bands 2, 7, 14, and 15.

A.2 PLPT Events That Support Provisional Maturity

A.2.1 ABI-FD_FHS11: Performance Test

Objective: Assess performance of FD product for an extended period that includes some but not all seasonal variability, to demonstrate operational readiness.
Start Time: At completion of Beta analysis and start of operational phase.
Duration: 24 weeks.
ABI Mode: Mode 3.
GOES-R Data Type(s): FD, Bands 2, 7, 14, and 15.
Provisional Success Criteria:

- Performance assessment documented in terms of the probability of fire detection, as a function of sub-pixel characteristics and omission and commission error rates for a large and wide range

of representative conditions. Representative conditions include the full range of biomes and surface types and seasons present within the Full Disk, including but not limited to wildfires in boreal forest, rainforest, wooded mountains, grassy plains, and agricultural burning during the seasons present during the Provisional period.

- Product deficiencies documented and remediation strategies in place for known issues.
- Impacts from challenges with upstream dependencies documented.
- Feedback from the primary users (NWS, NESDIS, NRL, etc.) is summarized and documented.
- Product is ready for potential operational use (user decision based on the user's established criteria) and for use in scientific publications to document product performance.

PLPT Analyst: Wilfrid Schroeder; 0.38 FTE.
Validation Data: Higher spatial resolution (Landsat-class) reference fire data.
Monitoring and Analysis Method: Deep-dive validation tool.

A.2.2 ABI-CONUS_FHS12: Performance Test

Same as ABI-FD_FHS11 except for:
Objective: Assess performance of CONUS product.
GOES-R Data Type(s): CONUS, Bands 2, 7, 14, and 15.

A.3 PLPT Events That Support Full Maturity

A.3.1 ABI-FD_FHS13: Performance Test

Objective: Assess performance of FD product for an extended period that includes seasonal variability, to demonstrate operational readiness.
Start Time: At completion of Provisional analysis and start of operational phase.
Duration: 36 weeks.
ABI Mode: Mode 3.
GOES-R Data Type(s): FD, Bands 2, 7, 14, and 15.
Full Success Criteria:

- Performance assessment determined in terms of the probability of fire detection, as a function of sub-pixel characteristics and omission and commission error rates for a large and wide range of conditions. Representative conditions include the full range of biomes and surface types present within Full Disk, including but not limited to wildfires in boreal forest, rainforest, wooded mountains, grassy plains, and agricultural burning during the all seasons.
- User concurs with Full maturity.

PLPT Analyst: Wilfrid Schroeder; 0.38 FTE.
Validation Data: Higher spatial resolution (Landsat-class) reference fire data.
Monitoring and Analysis Method: Deep-dive validation tool.

A.3.2 ABI-CONUS_FHS14: Performance Test

Same as ABI-FD_FHS13 except for:
Objective: Assess performance of CONUS product.
GOES-R Data Type(s): CONUS, Bands 2, 7, 14, and 15.

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

B.1 Data Set #1: GOES WFABBA fire product, fire locations, characterizations, and metadata
Description: GOES WFABBA fire product, fire locations, characterizations, and metadata.
Storage Location: CIMSS WFABBA processing (local machines using data from SSEC datacenter); fallback to NESDIS operational WFABBA product if needed.
Access Process: ~1 MB/day, automated script operating on local machines; FTP from NESDIS if needed.
Spatial Coverage: Western Hemisphere geostationary.
Temporal Coverage: 15 min CONUS, 3 hour FD.
Contingency: rely on NESDIS WFABBA data. If not available from NESDIS either, rely on MODIS, VIIRS, and AVHRR.

B.2 Data Set #2: MODIS L2 fire product, fire locations
Description: MODIS L2 fire product, fire locations.
Storage Location: NASA FTP server.
https://earthdata.nasa.gov/data/near-real-time-data/data/instrument/modis.
Access Process: 200 GB, automated script retrieves data over Western Hemisphere once available, checks every hour.
POC: N/A Online access
Spatial Coverage: Global.
Temporal Coverage: Approximately every 12 hours.
Contingency: Rely on GOES and VIIRS.

B.3 Data Set #3: VIIRS L2 fire product, fire locations for use in routine analysis
Description: VIIRS L2 fire product, fire locations for use in routine analysis.
Storage Location: NOAA CLASS http://www.nsof.class.noaa.gov/saa/products/welcome site.
Access Process: Automated script retrieves data over Western Hemisphere once available, checks every hour.
POC: N/A Online access
Spatial Coverage: Global.
Temporal coverage: Daily.
Contingency: rely on other sources, ie MODIS, AVHRR, GOES WFABBA, etc.

B.4 Data Set #4: AVHRR L2 fire product, fire locations for use in routine analysis
Description: AVHRR L2 fire product, fire locations for use in routine analysis.
Storage Location: USGS http://glovis.usgs.gov.
Access Process: Automated script retrieves data over Western Hemisphere once available, checks every hour.
POC: N/A Online access
Spatial Coverage: Global.
Temporal Coverage: Daily.
Contingency: Rely on other sources, ie MODIS, VIIRS, GOES WFABBA, etc.

B.5 Data Set #5: Landsat-8 30 m resolution 2D fire mask (fire/no-fire, water, and cloud classes).
Description: Landsat-8 data composed of 30 m resolution 2D fire mask including fire/no-fire, water, and cloud classes.
Storage Location: USGS (online archive, password protected).

Access Process: semi-automated, user defines Worldwide Reference System (WRS)-2 paths and rows and interval of interest, script downloads data from USGS archive.
POC: N/A Online access
Spatial Coverage: Global, approximately 180 x 180 km for each individual image.
Temporal Coverage: Revisit every 16 days.
Contingency: Rely on European Space Agency's (ESA) Sentinel-2 Multi-Spectral Imager (MSA) 20 m resolution data.

B.6 Data Set #6: Field Campaign Data

Description: the GOES-R field campaign planned for the April-June timeframe in 2017 involves AVIRIS on the ER-2. However, AVIRIS provides the same level of information as Landsat-8 data, so it adds no value for FHS validation. If USDA Forest Service-operated fire imaging systems are flown during the validation effort, the data will be used.
Source: Airborne Visible / Infrared Imaging Spectrometer (AVIRIS) on the ER-2 and/or USDA Forest Service-operated fire imaging systems.
Access Process: TBD
POC: Francis Padula
Frequency of Transmission: TBD.
Contingency: None.

C. Appendix C: Tools

C.1 Tool #1: Commercial Off-The-Shelf (COTS)/CIMSS FHS Routine Validation Tool

Location: University of Wisconsin-Madison/SSEC/CIMSS.

Description: A combination of COTS and CIMSS in-house developed software consisting of:

- Proxy data generator (output from Algorithm Integration Team (AIT) Advanced Himawari Imager (AHI) fire data as proxy).
- Routine validation scripts in Interactive Data Language (IDL).
- Perl L2 to Keyhole Markup Language (KML) converter.

Converters read in polar data, generate simple statistics, and convert data to KML for visualization. McIDAS is used to visualize the L1 ABI data and examine the data values in a Graphical User Interface (GUI). Google Earth (GE) (or GE based system such as SSEC's Real Earth) is used to overlay fire products for visual comparison. IDL routines perform co-locations for individual fires and for clusters of fires and generate statistics on matches. Downloading data files for routine analysis of fire detection data from polar orbiters is automated.

Developer: Chris Schmidt.

Development Schedule: Perl L2 to KML converter development June-July 2015.

Data Dependencies: L2 files for VIIRS, MODIS, AVHRR, ABI Fires data, and GOES WFABBA data.

Testing Accomplished or Planned: Perl L2 to KML converter testing through September 2015 using AHI and DOE test data as ABI proxy.

POC: Chris Schmidt.

C.2 Tool #2: Cooperative Institute for Climate Studies (CICS) deep-dive tool

Location: University of Maryland.

Description: CICS in-house developed software that consists of:

- IDL code to handle the production of reference fire data using higher spatial resolution Landsat-class data.
- IDL code to handle the co-location of GOES-R/ABI FHS and reference fire data, and retrieval of summary data validation results including graphical and tabular outputs.
- Selection, ordering and downloading of reference data files for deep-dive tool require analyst supervision. Pre-processing of reference data sets is accomplished using automated routines (IDL) that generate the corresponding reference fire data for the deep-dive tool (i.e., fire locations, size, temperature, radiative power).

Developer: Wilfrid Schroeder.

Development Schedule: Baseline tool was finalized in September 2015.

Data Dependencies: preprocessed reference data sets generated by automated stand-alone routines connected in series to deep-dive software package.

Testing Accomplished or Planned: Testing was performed in September-October 2015 using GOES-R/ABI FHS proxy files from a Data Operations Exercise (DOE).

POC: Wilfrid Schroeder.

D. Appendix D: Acronyms

Acronym	Definition
ABI	Advanced Baseline Imager
AHI	Advanced Himawari Imager
AIT	Algorithm Integration Team
AVHRR	Advanced Very High Resolution Radiometer
AVIRIS	Airborne Visible / Infrared Imaging Spectrometer
AWG	Algorithm Working Group
Cal/Val	Calibration and Validation
CCR	Configuration Change Request
CICS	Cooperative Institute for Climate Studies
CIMSS	Cooperative Institute for Meteorological Satellite Studies
CLASS	Comprehensive Large Array-data Stewardship System
CMI	Cloud and Moisture Imagery
CONUS	Continental United States
COTS	Commercial Off-The-Shelf
CWG	Calibration Working Group
DOE	Data Operations Exercise
ER-2	Earth Resources 2
ESA	European Space Agency
FD	Full Disk
FHS	Fire Hot Spot
F&PS	Functional Performance Specification
FRP	Fire Radiative Power
FTE	Full-Time Equivalent
FTP	File Transfer Protocol
GE	Google Earth
GOES	Geostationary Operational Environmental Satellite
GOES-R	GOES R-Series
GORWG	GOES-R Series Operational Requirements Working Group
GRB	GOES Rebroadcast
GUI	Graphical User Interface
HRR	Handover Readiness Review
IDL	Interactive Data Language
KML	Keyhole Markup Language
L1b	Level 1b
L2	Level 2
McIDAS	Man-computer Interactive Data Access System

MODIS	Moderate Resolution Imaging Spectroradiometer
MOST	Mission Operations Support Team
MSFC	Marshall Space Flight Center
MSI	Multi-Spectral Imager
NASA	National Aeronautics and Space Administration
NCEI	National Centers for Environmental Information
NCEI-CO	NCEI - Colorado
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NRL	Naval Research Lab
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
PRO	Product Readiness and Operations
PUG	Product User's Guide
PSE	Program System Engineering
PS-PVR	Peer Stakeholder-Product Validation Review
QA	Quality Assurance
RIMP	Readiness, Implementation and Management Plan
SPOT	System Performance Operational Test
SSEC	Space Science and Engineering Center
STAR	Center for Satellite Applications and Research
TBD	To Be Determined
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VIIRS	Visible Infrared Imaging Radiometer Suite
WFABBA	Wildfire Automated Biomass Burning Algorithm
WRS	Worldwide Reference System