



# **Geostationary Operational Environmental Satellite (GOES) – R Series**

## **ABI L2+ Hurricane Intensity Estimation (HIE) Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)**

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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.

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

Figure 1. GOES-R product maturity levels.

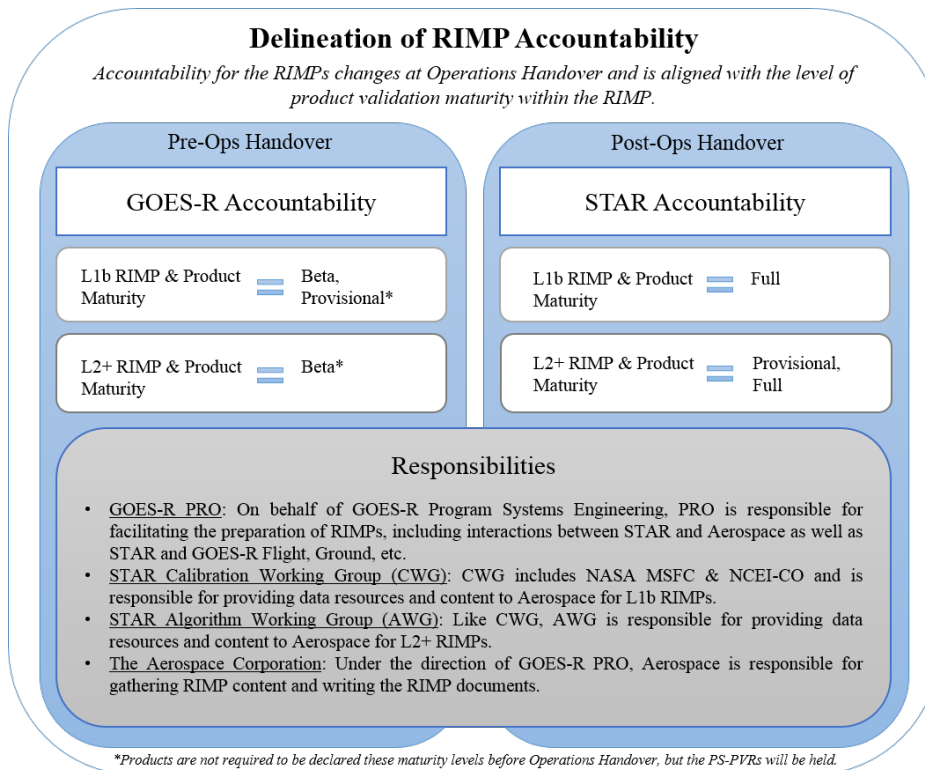


Figure 2. Delineation of accountability between GOES-R and STAR.



# 1. Hurricane Intensity Estimation Validation Overview

This Readiness, Implementation, and Management Plan (RIMP) covers all validation stages of the GOES-R Advanced Baseline Imager (ABI) Hurricane Intensity Estimation (HIE) Level 2 product. There are three stages in the validation process, Beta, Provisional, and Full maturity. Each stage is defined by PLPTs, which guide the overall validation process. This RIMP includes a summary of the methods and tools employed to prove that HIE has met a given validation stage. Appendices are included that present more detail on each PLPT and detail on the different data sets employed in the validation of the HIE product.

The HIE retrieves the position and strength of the tropical storm based on the maximum surface wind speed via the Dvorak technique and improved methodologies.

The HIE team has identified 5 PLPTs with success criteria to achieve Beta maturity. There is one additional PLPT defined to attain Provisional maturity and one more to attain Full maturity. The first Beta maturity PLPT will verify that the product is generated at the required frequency: every 30 min of the day for every Full Disk (FD) during a tropical cyclone event(s) with the instrument in Mode 3. The second Beta maturity PLPT is planned to verify that the product is not generated every 30 min of the day for every FD when a tropical cyclone event(s) is not occurring. The third and fourth Beta maturity events are similar to the first two Beta PLPTs, but with the instrument in Mode 4. Finally, the fifth Beta maturity PLPT will assess the accuracy and precision of the product with the instrument in Mode 3 and 4. The Mission Requirements Document (MRD) and Functional and Performance Specification (F&PS) specifications state that, for this product, they are to meet an accuracy of 6.5 m/s over ocean and a precision of 8.0 m/s over ocean.<sup>3</sup>

The success criteria for the first and third Beta maturity validation PLPTs are that the product generated during tropical cyclone events falls within the expected measurement range. The success criterion for the second and fourth Beta maturity events is that the product is not generated when a tropical cyclone is not occurring. The analyses will be carried in parallel during one week after the start of PLPT. Success of the fifth Beta maturity PLPT is achieved when the HIE product is quantitatively analyzed (accuracy and precision) with shortfalls documented over the limited time frame of these events.

The PLPTs that support the Beta maturity are listed below; details are in Appendix A.

- **ABI-FD\_HIE01:** verify that product is generated and distributed every 30 min of the day for every FD during a tropical cyclone event(s) while in ABI Mode 3 and the product falls within the expected measurement range.
- **ABI-FD\_HIE02:** verify that product is not generated every 30 min of the day for every FD when a tropical cyclone event(s) is not occurring while ABI is in Mode 3.
- **ABI-FD\_HIE03:** verify that product is generated and distributed every 30 min of the day for every FD during a tropical cyclone event(s) while ABI is in Mode 4 and the product falls within the expected measurement range.
- **ABI-FD\_HIE04:** verify that product is not generated every 30 min of the day for every FD when a tropical cyclone event(s) is not occurring while ABI is in Mode 4.
- **ABI-FD\_HIE05:** assess accuracy and precision of product and identify issues that can degrade the product performance while the instrument is in Mode 3 and in Mode 4 (must have tropical cyclones present part of the time).

The following Table identifies the frequency cadences of each scan type for Modes 3 and 4 for the HIE product, defined by both the GOES-R F&PS and the Product User’s Guide (PUG). The F&PS and PUG cadences are matched. The frequencies shown in the HIE – F&PS row (4<sup>th</sup> 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		
Scan Type	FD	CONUS	Mesoscale	FD	CONUS	Mesoscale
Scan Freq	15 min	5 min	30 sec	5 min	5 min*	N/A
HIE – F&PS	30 min	N/A	N/A	30 min	N/A	N/A
HIE - PUG	30 min	N/A	N/A	30 min	N/A	N/A

Table 1. HIE product and verification cadences.

One additional PLPT has been defined to attain Provisional maturity. The PLPT event that supports Provisional maturity is listed below and the details are in Appendix A.

- **ABI-FD\_HIE06:** assess accuracy and precision of HIE product and identify any issues that can degrade the product performance while the instrument is in Mode 3 and 4 – Convey to the user community that the product is ready for operational assessment (must have tropical cyclones present part of the time).

This event is planned to be carried out at the end of the PLPTs for a period of 24 weeks during at least a portion of hurricane season. The success criteria for the Provisional maturity PLPT for the HIE product is generated over a large and wide but limited range of representative (not seasonally representative) number of tropical cyclones for all required Modes (FD every 30 min):

- 1) Has been assessed sufficiently to characterize its accuracy and precision as well as the product limitations, and to identify any potential fixes and improvements needed to satisfy the Mission Requirements Document (MRD) specifications.
- 2) Its accuracy and precision does not have to be met to attain provisional status, however, if they do not do so, the reasons behind not meeting these requirements must be documented, to include reporting of incidents/issues as an Algorithm Discrepancy Report (ADR) for discussion at the Algorithm Action Review Team (AART).
- 3) It has remediation strategies in place for known issues.
- 4) It is has been established as ready for operational assessment (user recommendation).

There is one PLPT that has been defined to attain Full maturity. This test is planned to start immediately after the Provisional maturity is attained and to be carried out for a period of 36 weeks (during at least part of hurricane season). This event is listed below and in in detail within Appendix A.

- **ABI-FD\_HIE07:** assess accuracy and precision of HIE product for a seasonal representative set of conditions and identify issues that can degrade the product performance while the instrument is in Mode 3 and in Mode 4. The product is operational (user feedback and approval) (must have tropical cyclones present part of the time).

The success criteria for the Full maturity test is similar to the Provisional success criteria, except that in this case the product will be generated during a seasonally-representative set of conditions that includes a number of tropical cyclones for the required modes.

All of the PLPTs for HIE make use of collocation, visualization and statistical analysis tools to generate statistical comparisons of the HIE intensity estimates with validation data.

The main source of data for HIE validation includes ground-based measurements from in-situ aircraft reconnaissance measurements of intensity, and Best Track estimates of tropical cyclone intensity maintained by the National Hurricane Center (NHC) (see Appendix B).

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

## 2. Schedule of Events

The HIE product Beta effort will be divided in two stages. The first one is to verify that with the sensor in Mode 3 and 4 that the product is generated/not generated every 30 min of the day for every FD during a tropical cyclone/when a cyclone is not occurring. This stage is planned to take 1 week (during which a tropical cyclone is present for at least part of the week) and it will provide an early assessment of the product characteristics. Although the product generation cadence is the OSPO responsibility, the verification of the generated product is the responsibility of the cal/val team. The second stage is to actually assess the accuracy and precision of the product and eventual areas of degraded performance, although over a limited number of tropical cyclones and/or independent measurements which is planned to last 5 weeks (during which tropical cyclones are present for at least part of the 5 weeks). The product performance assessment will be conveyed to the user community. These events will be carried out during the 42 days of PLPT (assuming the above requirement for tropical cyclone activity).

The details of the GOES-R validation schedule are also shown in Figure 3. 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. The L1b and L2 CMI 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).

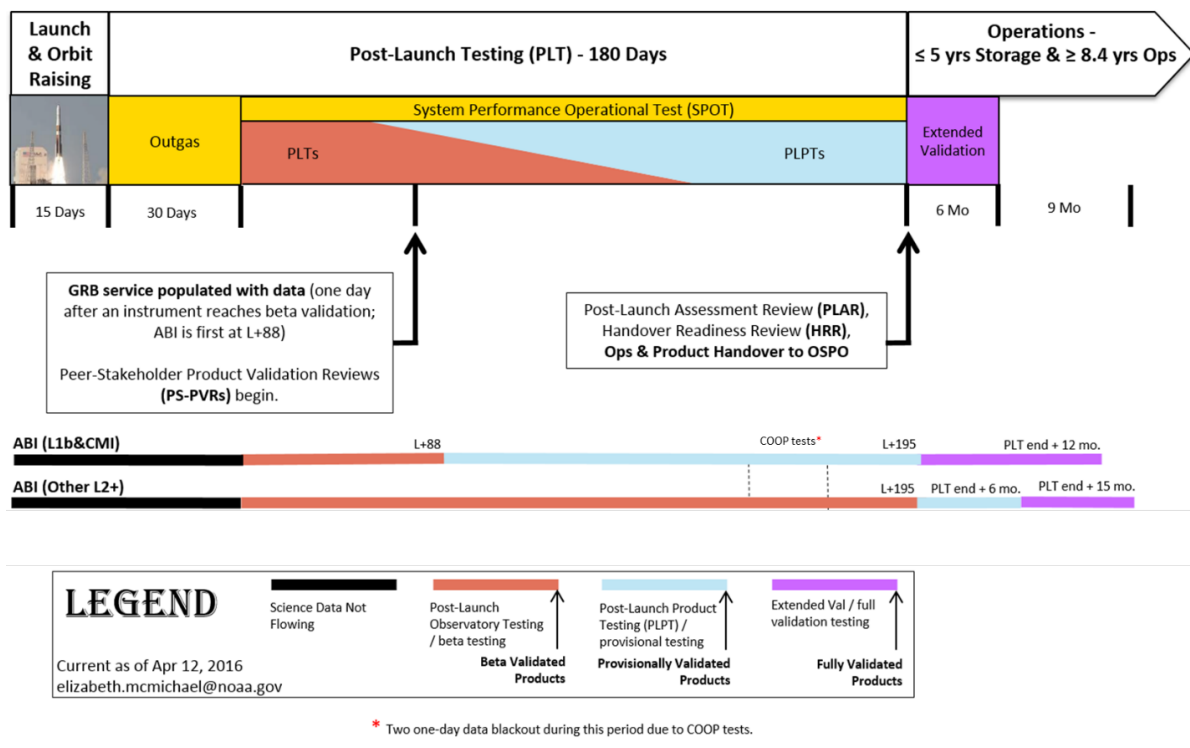


Figure 3. Schedule of events.

The verification of events include:

- Current – December 2015: finish testing all HIE validation tools.
- Current – September 2016: evaluate results using data from DOE-3 and -4.
- Current – October 2016: test and evaluate algorithm with Himawari 8 data.
- December 2016: final version of the HIE tools ready to run on for GOES-R cal/val.
- L+44 days: Starts System Performance Operational Test (SPOT).
- L+155 days: PLPT starts – Beta maturity events start.
- L+195 days (PLPT start+6 weeks): Beta maturity ends - handover to OSPO.
- L+197 days+24 weeks (6 months): Provisional maturity verification ends – Full testing starts.
- L+197 days+24 weeks+36 weeks (9 months): Full maturity verification ends.

The GOES-R Operations phase begins after handover and marks 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 month period for L2 products to reach Full maturity, 15 months after handover.

Note that the HIE product validation requires the occurrence of tropical cyclone activity. If tropical cyclones do not occur during the scheduled period, a deferred schedule (probably to the next hurricane season) will be worked out for this particular product.

There will be a set of pre-launch preparation activities that include the generation and test of tools and models with simulated ABI imagery as well as L1 and L2 data sets as indicated in Section 7.

### **3. Roles and Responsibilities**

#### **3.1 Primary Point of Contact**

The primary point of contact (POC) for leading the HIE validation effort and algorithm updates is Jaime Daniels.

#### **3.2 GOES-R Point of Contact**

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

#### **3.3 Test Analyst/Engineer**

Tim Olander will lead the analysis of the PLPTs under Chris Velden's direction.

#### **3.4 GOES-R Feedback**

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

#### **3.5 Level of Effort**

Tim Olander and Chris Velden will be at 0.90 FTE and 0.10 FTE, respectively.

## **4. Tools**

A set of tools have been identified as necessary for all the PLPTs for each individual storm. Both tools are currently running in real-time on the CIMSS Tropical Cyclone page for all global storms (even though this is not a requirement of the HIE). Each of these tools is detailed in Appendix C. They will be delivered to the cal/val system in December, 2015. A detailed description of the tools used for the HIE validation PLPTs can be found in Appendix C.

## **5. Analysis Methods**

The main validation approach will be to compare HIE estimates with “ground truth” measurements consisting of in situ aircraft measurements of intensity, and/or official tropical cyclone Best Track estimates of intensity and position available at 6 hours intervals from NHC. Categorical HIE differences from “ground truth” will provide an assessment of any intensity estimate issues. The methods/tools used to analyze the Beta, Provisional and Full events are the same.



## 6. Output Artifacts

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

### 6.1 Beta Maturity Artifacts

The criteria for declaring Beta maturity are at the completion of the Beta analysis, a report will be prepared containing an initial quantitative assessment, based on a limited data set, of accuracy and precision of the HIE product as a function of characteristic parameters (e.g. wind speed, hurricane intensity value and brightness temperature for Band 13, regression coefficients, latitude and longitude coordinates, etc.) The report will also discuss issues identified with the product. The product accuracy and precision are specified in section 1.

**6.1.1** These tests of priority 1 all must pass in order to achieve Beta maturity:

- ABI-FD\_HIE01
- ABI-FD\_HIE02
- ABI-FD\_HIE03
- ABI-FD\_HIE04
- ABI-FD\_HIE05

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

### 6.2 Provisional Maturity Artifacts

The criteria for declaring Provisional are performance metrics results for a longer period and larger range of representative conditions. These results will be presented at PS-PVRs. The specific Provisional maturity success criteria includes:

- Documented impacts from challenges with upstream dependencies;
- Documented feedback from the primary user (NWS) (if available);
- Product Geographic Coverage/Conditions: FD
- Product Horizontal Resolution: 2 km
- Product Mapping Accuracy: 1 km
- Product Measurement Range: Dvorak hurricane intensity scale values of 1.5 - 8 or leading to wind speeds of 12.8 m/s (25 knots) to 87.5 m/s (170 knots)
- Product Measurement Accuracy: 6.5 m/s over ocean
- Product Measurement Precision: 8.0 m/s over ocean
- Temporal Coverage Qualifier: Day and Night
- Product Extent Qualifier: Quantitative out to at least 65 degrees LZA (Threshold)
- Cloud Cover Conditions Qualifier: Not Applicable
- Accuracy and precision MRD/F&PS specifications do not have to be met to attain Provisional status, however, if they do not do so, the reasons behind not meeting these requirements must be documented
- Have remediation strategies in place for known issues
- Product is ready for potential operational assessment

**6.2.1** The following test of priority 1 must pass in order to achieve Provisional maturity:

- ABI-FD\_HIE06

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

### 6.3 Full Maturity Artifacts

The Full Validation stage will include the results over a seasonal representative set for all the required modes (see condition and modes as used for validation events indicated in Appendix A), and as a function of characteristic parameters similar to those reported for Beta. Note that the HIE product performance can only be assessed in the presence of a tropical cyclone storm.

**6.3.1** The following test of priority must pass in order to achieve Full maturity:

- ABI-FD\_HIE07

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

#### **6.4 Key Artifacts**

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

#### **6.5 More Output Artifacts**

The product limitations, areas where it does not satisfy the MRD specifications and the remediation strategies will be documented. The feedback from the primary user (NWS) will be requested and documented if available. International partners will receive test data and results of validation and asked to comment. The Provisional and Full validation presentations will include a summary of user feedback received during the respective validation periods. The Provisional maturity can be assigned even if this product evaluation by the user is not available.

#### **6.6 Delivery Schedule**

The delivery schedule of artifacts for the HIE 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

The following activities have been completed during pre-launch:

- Secured availability of resources (compute servers, local storage).
- Verified tool readiness: completion and test of collocation and visualization tools.
- Verified accessibility to L1b data sets, L2+ product data sets and L2+ diagnostic data sets
- Simulated ABI imagery (FD).
- Identified validation reference data collection: Operational Best Track seasonal database (wind and MSLP), Aircraft reconnaissance observations, Operational Forecast Center (OPCen) intensity estimates, GOES HIE estimates.

## 8. References

- [1] PLPT\_VE\_List\_L2\_v1\_0\_20141022.xlsx.
- [2] CalValPlan\_Vol2\_L2\_v1-1-draft-redlines\_inc-ERB\_comments\_v2a - Clean - BobEdits.docx.
- [3] MRD\_v3\_17.pdf and FSP.
- [4] GOES-R AWG Product Validation Tool Development: HIE.
- [5] GOES-R Series Ground Segment Project Algorithm Change Management Plan.
- [6] GOESR-CVCT-PLPT\_BriefingToNOAA-IAC\_2015-02-03\_FINAL.pptx – Shortcut.
- [7] HIE\_Validation\_Table\_v2\_rico.docx.
- [8] GOES-R\_ABI\_ATBD\_Validation\_Tools\_/HIE\_Ver1.0.docx.

## A. Appendix A: Validation Events

### A.1 PLPT Events that Support Beta Maturity

#### A.1.1 Event Name: ABI-FD\_HIE01

**Objective:** Certify that product is generated every 30 min of the day for every FD during a tropical cyclone event(s).

**Description:** Inspection of Hurricane Intensity Estimate.

**Start Time:** During PLPT.

**Duration:** 1 week (during a tropical cyclone event).

**ABI Mode:** Mode 3.

**GOES-R Data Type(s):** FD every 30 min.

**Beta Success Criteria:** Product is generated for tropical cyclone events and falls within expected measurement range. Product must be received at the validation site every ½ hour of the day for every FD.

**Dependencies:** Band 13 FD image generated by the ground system and delivered to the cal/val team within the FD cadence.

**PLPT Lead:** Chris Velden

**PLPT Analyst:** Tim Olander

**Monitoring and Analysis Method:** Product inspection; Compare to reference/ground truth data<sup>2</sup>.

#### A.1.2 Event Name: ABI-FD\_HIE02

**Objective:** Verify that product is not generated every 30 min of the day for every FD when a tropical cyclone event(s) is not occurring.

**Description:** Null test; Hurricane Intensity Estimate.

**Start Time:** During PLPT.

**Duration:** 1 week (no tropical cyclone events occurring).

**ABI Mode:** Mode 3.

**GOES-R Data Type(s):** FD every 30 min.

**Beta Success Criteria:** Product is not generated.

**Dependencies:** None.

**PLPT Lead:** Chris Velden

**PLPT Analyst:** Tim Olander

**Monitoring and Analysis Method:** Product inspection; compare to reference/ground truth data.<sup>2</sup>

#### A.1.3 Event Name: ABI-FD\_HIE03

Same as ABI-FD\_HIE01 except for:

**ABI Mode:** Mode 4

#### A.1.4 Event Name: ABI-FD\_HIE04

Same as ABI-FD\_HIE02 except for:

**ABI Mode:** Mode 4

#### A.1.5 Event Name: ABI-FD\_HIE05

**Objective:** Assess accuracy and precision of HIE product.

**Description:** Compare to reference/ground truth data. Reference [2] Section 3.8.

**Start Time:** During PLPT.

**Duration:** 5 weeks (must have tropical cyclones present part of the time).

**ABI Mode:** Mode 3 and 4.

**GOES-R Data Type(s):** FD every 30 min.

**Beta Success Criteria:** Product meets F&PS specifications for a very limited (i.e., not seasonally representative) number of independent comparisons.

**Dependencies:** Band 13 images generated by the ground system and delivered to the cal/val team within the FD cadence.

**PLPT Lead:** Chris Velden

**PLPT Analyst:** Tim Olander

**Monitoring and Analysis Method:** Detailed comparison to reference/ground truth data<sup>2</sup>.

## A.2 PLPT Events that Support Provisional Maturity

### A.2.1 Event Name: ABI-FD\_HIE06

**Objective:** Assess accuracy and precision of product and identify any issues that can degrade the product performance while the instrument is in Mode 3 or 4 – Convey to the user community that the product is ready for operational assessment.

**Description:** Compare to reference/ground truth data. Reference: Cal-Val Plan (P410-R-PLN-0194) Section 3.8.

**Start Time:** PLPT+6 weeks.

**Duration:** 24 weeks (during at least a portion of the hurricane season).

**ABI Mode:** Mode 3 and 4.

**GOES-R Data Type(s):** FD every 30 min.

**Provisional Success Criteria:** The HIE accuracy and precision assessed over large (not seasonally representative) number of tropical cyclones, sufficient to characterize the product so that challenges and impacts can be documented and conveyed to the user community (see below for more details).

**PLPT Lead:** Chris Velden

**PLPT Analyst:** Tim Olander

**Dependencies:** Band 13 imagery generated by the ground system and delivered to the cal/val team within the FD cadence.

**Monitoring and Analysis Method:** Product Inspection and Detailed comparison to reference/ground truth data<sup>2</sup>.

## A.3 PLPT Events that Support Full Maturity

### A.3.1 Event Name: ABI-FD\_HIE07

**Objective:** Assess accuracy and precision of HIE product and identify any issues that can degrade the product performance while the instrument is in Mode 3 and 4 – Convey to the user community that the product is ready for operational use.

**Description:** Compare to reference/ground truth data. Reference: [2] Section 3.8.

**Start Time:** PLPT+30 weeks.

**Duration:** 36 weeks (during at least a portion of the hurricane season).

**ABI Mode:** Mode 3 and 4.

**GOES-R Data Type(s):** FD every 30 min.

**Full Success Criteria:** The HIE accuracy and precision assessed over a seasonally-representative number of tropical cyclones. Product meets MRD specifications. Potential product limitations specified. Accuracy and precision do not have to be met to attain Full validation, however, if they do not do so, the reasons behind not meeting these requirements must be documented. Ready for full operational use (user feedback, see below). Product specifications as for Provisional maturity.

**Dependencies:** Band 13 imagery generated by the ground system and delivered to the cal/val team within the FD cadence.

**PLPT Lead:** Chris Velden

**PLPT Analyst:** Tim Olander

Effective Date: Date of Last Signature  
Responsible Organization: GOES-R Ground Segment/Code 416

416-R-RIMP-0330  
Version 1.0

**Monitoring and Analysis Method:** Product inspection and detailed comparison to reference/ground truth data<sup>2</sup>

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

### **B.1 Data Set #1: Aircraft Reconnaissance**

**Description:** Aircraft reconnaissance measurements of tropical cyclone (TC) intensity (central pressure or maximum sustained wind speed estimate) and TC position. Availability dependent upon aircraft flight frequency.

**Storage location:** NHC public FTP site: Forecast “f-deck” files or NOAAPORT.

**Access Process:** Download from NOAAPORT via OSPO McIDAS or from ftp.nhc.noaa.gov/atcf/fix directory - 4.8 MB/day.

**POC:** nhc.noaa.gov.

**Temporal Coverage:** Dependent on aircraft flights per storm.

**Contingency:** If data is not available, dataset #2 or #3 can be used instead.

### **B.2 Data Set #2: NHC Best Track**

**Description:** NHC “Working Best Track” estimates of TC intensity and position - Available at 6 hour intervals during tropical cyclone events.

**Storage location:** HHC public FTP site – Best Track “b-deck files.

**Access Process:** Download from Best Track ftp site: ftp.nhc.noaa.gov/atcf/btk directory – 100KB/day.

**POC:** ftp.nhc.noaa.gov.

**Spatial Coverage:** Storm event.

**Temporal Coverage:** 4 times daily at 6 hour intervals /storm.

**Contingency:** None - if data is not available, dataset #3 could be used for a degraded comparison.

### **B.3 Data Set #3: NHC ATCF Forecast**

**Description:** NHC ATCF Forecast or NHC Discussion -Files contain official NHC current and forecast TC intensity and position. ATCF file contains Discussion forecast information as well as additional information (e.g. critical wind speed radii). Available at 6 hour intervals.

**Storage location:** NHC public FTPsite: Fix “a-deck” files.

**Access Process:** Available through download from NHC FTP (ftp.nhc.noaa.gov/atcf/fst or ftp.nhc.noaa.gov/atcf/dis for the discussion) or discussions available on NOAAPORT (via OSPO McIDAS) – 100KB/day.

**POC:** ftp.nhc.noaa.gov/atcf/fst.

**Spatial Coverage:** Storm event.

**Temporal Coverage:** 4 times daily at 6-hour intervals per storm.

**Contingency:** Is a support data. Data from B2 and B1 should be used instead if available.



## C. Appendix C: Tools

### C.1 C.1 Tool #1: runHIEstats.scr

**Location:** Local computers. Currently running in real-time on the CIMSS Tropical Cyclone page for all global storms. The URL is <http://tropic.ssec.wisc.edu/real-time/adt/validation/ADT-ALL-2016.html> for 2016 stats, or [ADT-ALL-2015.html](http://tropic.ssec.wisc.edu/real-time/adt/validation/ADT-ALL-2015.html) for 2015 stats.

**Description:** Performs comparisons of real-time HIE intensity estimates versus current NHC Working, Best Track intensity estimates or aircraft reconnaissance in-situ measurements.

**Developer:** Tim Olander.

**Development Schedule:** December 2015.

**Data Dependencies:** Band 131.

**Data Sets:** Aircraft reconnaissance, Best Track, NHC forecast, GOES-R data.

**Testing Accomplished or Planned:** 95% with the remaining 5% completed with DOE data.

**POC:** Tim Olander.

### C.2 C.2 Tool #2: runHIEstats-season.scr

**Location:** Local computers. Currently running in real-time on the CIMSS Tropical Cyclone page for all global storms. The URL is <http://tropic.ssec.wisc.edu/real-time/adt/validation/ADT-ALL-2016.html> for 2016 stats, or [ADT-ALL-2015.html](http://tropic.ssec.wisc.edu/real-time/adt/validation/ADT-ALL-2015.html) for 2015 stats.

**Description:** Provide statistics for the entire season. Combines all the storms.

**Developer:** Tim Olander.

**Developer Schedule:** December 2015.

**Data Dependencies:** Band 13<sup>1</sup>.

**Data Sets:** Aircraft reconnaissance, best track, NHC forecast, GOES-R data.

**Testing Accomplished or Planned:** 95% with the remaining 5% completed with DOE data.

**POC:** Tim Olander.

## D. Appendix D: Acronym List

<b>Acronym</b>	<b>Definition</b>
<b>AART</b>	Algorithm Action Review Team
<b>ABI</b>	Advanced Baseline Imager
<b>ADR</b>	Algorithm Discrepancy Report
<b>ATCF</b>	Automated Tropical Cyclone Forecast
<b>AWG</b>	Algorithm Working Group
<b>BTs</b>	Brightness Temperatures
<b>Cal/Val</b>	Calibration and Validation
<b>CCR</b>	Configuration Change Request
<b>CIMSS</b>	Cooperative Institute for Meteorological Satellite Studies
<b>CMI</b>	Cloud and Moisture Imagery
<b>CONUS</b>	Continental United States
<b>CWG</b>	Calibration Working Group
<b>DOE</b>	Data Operations Exercise
<b>F&amp;PS</b>	Functional and Performance Specification
<b>FD</b>	Full Disk
<b>FTE</b>	Full-Time Equivalent
<b>FTP</b>	File Transfer Protocol
<b>GOES</b>	Geostationary Operational Environmental Satellite
<b>GOES-R</b>	GOES R-Series
<b>GORWG</b>	GOES-R Series Operational Requirements Working Group
<b>GRB</b>	GOES Rebroadcast
<b>HIE</b>	Hurricane Intensity Estimation
<b>HRR</b>	Handover Readiness Review
<b>L1b</b>	Level 1b
<b>L2</b>	Level 2
<b>LZA</b>	Local Zenith Angle
<b>McIDAS</b>	Man-computer Interactive Data Access System
<b>MOST</b>	Mission Operations Support Team
<b>MRD</b>	Mission Requirements Document
<b>MSFC</b>	Marshall Space Flight Center
<b>MSLP</b>	Mean Sea Level Pressure
<b>NASA</b>	National Aeronautics and Space Administration
<b>NCEI</b>	National Centers for Environmental Information
<b>NCEI-CO</b>	NCEI - Colorado
<b>NHC</b>	National Hurricane Center
<b>NWS</b>	National Weather Service
<b>OPCen</b>	Operational Forecast Center
<b>OSPO</b>	Office of Satellite and Product Operations

<b>Acronym</b>	<b>Definition</b>
<b>PLAR</b>	Post-Launch Assessment Review
<b>PLPT</b>	Post-Launch Product Test
<b>PLT</b>	Post-Launch Test
<b>POC</b>	Point of Contact
<b>PRO</b>	Product Readiness and Operations
<b>PSE</b>	Program System Engineering
<b>PS-PVR</b>	Peer Stakeholder-Product Validation Review
<b>PUG</b>	Product User's Guide
<b>QA</b>	Quality Assurance
<b>RIMP</b>	Readiness, Implementation and Management Plan
<b>SPOT</b>	System Performance Operational Test
<b>STAR</b>	Center for Satellite Applications and Research
<b>TBD</b>	To Be Determined