GOES-R L1b Readiness Implementation and Management Plan

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Outline

• What is a RIMP?
• Data Product Validation Overview
• ABI
• GLM
• Space Weather
• Summary
What is a RIMP?
Readiness, Implementation and Management Plan

- Readiness Implementation and Management Plan (RIMP)
  - Provides a top-level plan for Cal/Val of GOES-R (GOES-16)
    • Team developed a L1b data product RIMP for each instrument
  - Documents top-level activities planned within each product maturity phase:
    • Beta: Post-Launch Tests (PLTs)
    • Provisional: Post-Launch Product Tests (PLPTs)
    • Full Validation: Post-Launch Product Tests (PLPTs)
  - PLPTs are defined by the Cal/Val teams for each instrument
  - Defines an overall guiding schedule of events
    • Changes to plan are expected
  - Documents roles, responsibilities and PoCs for activities during all three levels of product maturity for each instrument
  - Connects primary tools and software packages to each PLPT that requires them
  - Defines output artifacts and Success Criteria to achieve each level of data product maturity
  - Identifies data sets and ground truth that are required by each PLPT
  - Provides background pre-launch activities relevant for post-launch data product testing

Level 1b RIMPs define the path for post-launch data product validation
What makes the GOES RIMP(s) special?

Coordination of Data Product Validation Plans

• Application of System Engineering Practices
  – *Mapping program requirements to the plan (PLPTs) in order to justify activities*
  – *Identification of requirements to execute each PLPT such as:*
    • S/W and analysis tools
    • Data requirements
    • Schedule and product interdependencies
  – *Structured ‘global’ view of Cal/Val*

• Provides a structured set of required Validation Events (VEs)
  – VE’s are PLTs (provided by the flight project) and PLPTs (provided by the Cal/Val team)
  – Identifies timing, scope tools needed, personnel, scheduling, required outputs/artifacts

• Identifies required validation reference data for each instrument to ensure diverse interdependencies are identified in Cal/Val planning
  – *Data access and storage summary*
  – *Spatiotemporal coverage needs*
  – *Science and programmatic points of contact*
  – *Data availability and contingencies*

**GOES-R RIMPs incorporate systems engineering practices to organize, justify and plan validation activities while identifying needed resources for successful completion**
What makes the GOES RIMPs ‘special’ (Cont’d)
Coordination of Data product Validation Plans

• Software tools required for each instrument
  – Provides description, development schedule and person responsible
  – Required testing and validation of each primary tool

• RIMPs identify and connect multiple interdependencies in order to define a robust path for data product validation
  – Increase potential for successful and timely data product validation

GOES-R RIMPs incorporate systems engineering practices to organize, justify and plan validation activities while identifying needed resources for successful completion
GOES-16 Instrument Complement

Satellite pictorial

- GOES-16 Contains 6 sensors grouped into 3 categories
  - Nadir pointing (ABI and GLM)
  - Solar pointing (EXIS and SUVI)
  - In situ (SEISS and MAG)
- Post-Launch tests (PLT) addressed by flight project
- Post-Launch data Product Tests (PLPTs) addressed by GOES-Product Readiness and Operations
  - Provisional data product maturity requires completion of several PLPTs
  - Full validation maturity extends the observations period and adds PLPTs
- RIMPs document the validation plan identify inter-dependencies, coordinate s/w tools and schedules

http://www.goes-r.gov/spacesegment/instruments.html
GOES-16 Post-Launch Science Product Validation
June 2017

Schedule updated as of June 2017

SOE: System Operation Exercise
MOST: Mission Operation Support Team
OSPO: Office of Satellite and Product Operations
A comprehensive suite of tests was developed to verify required on-orbit performance for the GOES-16 ABI

- Inter-satellite, ground, and airborne comparisons
- On-board calibration tests
- Vicarious calibration targets – Moon, deserts, clouds
- Landmarks – stars, coastlines
- Self-consistency tests – frame-to-frame, channel-to-channel, swath-to-swath

The tests use a combination of on-board and vicarious targets and comparisons with other coincident satellite and terrestrial measurements to assess ABI imagery

- Radiometric calibration
- Spatial resolution
- Geolocation accuracy
ABI Validation Overview
Advanced Baseline Imager

- ABI post-Launch Product Tests (PLPTs)
  - *Provisional validation requires 13 tests or ‘validation events’*
  - *All events except PLPT 09 are performed with routine imagery – N/S scans to measure detector uniformity*

- Graphic of ABI Validation Events
  - *PLT tests (blue)*
    - ‘C’ implies part of Radiometric Calibration
    - ‘E’ is defined as an Engineering test
    - ‘R’ denotes a reserve test
  - *PLPT tests for Provisional (Green)*
    - IR sounding and VNIR validation utilizing other instruments and models
    - Data and performance monitoring
    - Image co-registration and navigation
    - North/South scans
  - *PLPT tests for Full maturity (Extended Validation) – 12 months to assess product maturity*
    - Extends period of evaluation to include full range of on-orbit and scene conditions
    - Adds refinement of spectral response functions and instrument characterization

- Considering Cal/Val as collection of validation events helps focus supporting efforts

*RIMPs provide a detailed breakout of each validation event in order to identify needed models, tools, data flow, scheduling and other logistical and technical details*
Post-Launch Product Tests (PLPTs) for ABI

Graphics representation of PLT and PLPT Validation Events for ABI
# PLPT Schedule for ABI Science Data Products

## Provisional and Full Validation Periods

<table>
<thead>
<tr>
<th>PLPT</th>
<th>Extended L1b/KPP Val</th>
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<tbody>
<tr>
<td><strong>Regular collections</strong></td>
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<tr>
<td>PLPT-09d</td>
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<tr>
<td>PLPT-03 – Equinox ±50 days</td>
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<td><strong>Infrequent collection opportunities</strong></td>
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<tr>
<td>PLPT-08 – Collected with 30 days of Beta maturity</td>
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<tr>
<td><strong>Frequent opportunities, infrequent collections</strong></td>
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### ABI-L1b-PLPT-01 IR Val. CrIS/IASI
- ABI-L1b-PLPT-02 IR Val. RTM
- ABI-L1b-PLPT-04 VNIR Val. VIIRS
- ABI-L1b-PLPT-05 VNIR Val. Sonoran
- ABI-L1b-PLPT-06 VNIR Val. RVS (Data collected during PLT)
- ABI-L1b-PLPT-07 Instr Perf Mon
- ABI-L1b-PLPT-09a-c,e-f NSS
- ABI-L1b-PLPT-10 INR Assessment and Trending
- ABI-L1b-PLPT-11 Co-Registration Assessment and Trending
- ABI-L1b-PLPT-12 Stitching Assessment and Trending
- ABI-L1b-PLPT-13 VNIR Val - DCC

### ABI-L1b-PLPT-03 Restricted Zone Performance
- ABI-L1b-PLPT-09d NSS (Lunar)

### ABI-L1b-PLPT-08 AD Converter

### ABI-L1b-EV-03 – Equinox ±50 days
- ABI-L1b-EV-15b,c – Many during Field Campaign

### ABI-L1b-EV-07 SRF
- ABI-L1b-EV-08 OOB Resp.
- ABI-L1b-EV-09 Solar Cal - Radiiances
- ABI-L1b-EV-10 Polarization
- ABI-L1b-EV-11 Int. Cal Monitoring
- ABI-L1b-EV-12 Inter-season B2B Cal
- ABI-L1b-EV-13 Cal Linearity Mon
- ABI-L1b-EV-14 Ghosting
- ABI-L1b-EV-15a NSS (Desert)
- ABI-L1b-EV-16 INR Trending
- ABI-L1b-EV-17 Co-Registration Trending
- ABI-L1b-EV-18 Stitching Trending
- ABI-L1b-EV-19 VNIR Val - DCC

### ABI-L1b-EV-03 Restricted Zone Performance
- ABI-L1b-EV-15 b,c NSS (Aircraft and UAS Field Campaign)
GLM Test Description Summary
Global Lightning Mapper

• Assess system performance for
  – Events (PLT)
  – Strokes (PLPT)
  – Flashes (PLPT)

• 9 PLTs and 12 PLPT series differentiated by the attributes of the verification system, site locations and the performance to be characterized
  – System attributes
    • Short range networks with high detection efficiencies and low false alarm rates
    • Very long range systems with low flash detection efficiencies but medium storm detection efficiencies, etc.
  – Performance assessment
    • False alarm/event rates
    • Detection efficiency
    • Filter algorithms
    • INR
    • Cloud radiance and trends
    • Event energy and trends

Large number of sites minimize the effects of the vagaries of weather on the Cal/Val assessment
**EXIS Test Description Summary**

**Solar Monitoring**

- Extreme ultraviolet and X-ray Irradiance Sensors
  - X-Ray Sensor (XRS)
  - Extreme Ultra-Violet Sensor (EUVS)
  - Solar Pointing Sensor (SPS) measures pointing of XRS
- Heritage sensors were part of previous GOES satellites
  - XRS and EUVS instrument has been modified slightly
- PLPT continues initial PLT checkout tests
  - Further in-depth analysis of EXIS calibration
  - Establishes a snap-shot of calibration in an on-orbit environment
  - Initial benchmark for long-term trending of EXIS performance
- Validation Events
  - EUVS model baseline and uncertainties
  - Bootstrap Degradation
  - XRS cross-over threshold
  - Scaling factors
  - Pointing and flare location
SEISS Test Description Summary

In Situ Monitoring

• SEISS Instruments Include
  – Magnetospheric Particle Sensor – Low energy (MPS-LO)
  – Magnetospheric Particle Sensor – High Energy (MPS-HI)
  – Solar and Galactic Proton Sensor (SGPS)
  – Energic Heavy Ion Sensor (EHIS)

• GOES-R period leveraged expertise from previous GOES
  – Energetic Particle Sensor / High Energy Proton and Alpha Detector (EPS/HEPAD)
  – Leveraged mature documentation

• PLPT Validation Events Include
  – SGPS Contamination Correction
  – MPS Cross comparisons
  – Cross-satellite comparison of trapped particles
  – Background trending

• Solar Conditions
  – Quiet and disturbed conditions needed
MAG Test Description Summary

In-Situ Monitoring

- GOES-16 Magnetometer
  - Magnetic field measurements with 5 times the temporal resolution (10 Hz) as previous
  - Two boom-mounted flux-gate magnetometers (6.3 and 8.5m from the boom baseplate)
  - Measurements from the two sensors are combined using the gradiometer algorithm in order to improve knowledge of the ambient fields

- GOES-R Cal/Val Planning leveraged expertise from previous instruments
  - Nearby spacecraft magnetometer measurements form the basis for validation

- PLPT Validation Events for provisional maturity
  - Comparison to models under quiet conditions
  - Low resolution cross-satellite inter-comparisons (1 minute data)

- Full Validation
  - Full resolution cross-satellite intercalibration (10 Hz data)
  - Detailed comparisons using gradiometer algorithm to other methods
  - Intercalibration (MLT) 90 quiet days required

- Time series of trending parameters are the primary validation artifacts
**SUVI Test Description Summary**

*Solar Monitoring*

- **SUVI Instrument**
  - *Normal incidence telescope in the Ritchey-Chrétien*
  - *Charge coupled device (CCD) at the Cassegrain focus*
  - *Six narrow wavelength bands image different features of the Sun*
  - *Baffles block stray light and energetic particles from reaching the CCD*

- **SUVI Heritage**
  - *Has commonality with:*
    - Solar and Heliospheric Observatory / Extreme Ultra-violet imaging Telescope (SOHO/EIT)
    - Solar Dynamic Observatory / Atmospheric Imaging Assembly (SDO / AIA)
  - *Breaks with previous GOES heritage and the Solar X-Ray Imager (SXI) by adding Imaging of the extreme U-V portion of the spectrum and evolving solar forecasting*
**SUVI Test Description Summary (cont’d)**

**Solar Monitoring**

- PLPT Validation Events (Provisional Maturity)
  - Defines 5 transitional PLTs that continue into Provisional validation PLPTs
  - Dark Current Characterization, Defective Pixels, Shutter Light Leakage
  - Guide telescope calibration and characterization
  - CCD temperature and detector performance trending
  - Begin intercalibration with well-known sources of established accuracy; Solar Dynamics Observatory (SDO) Atmospheric Imaging Assembly (AIA)

- Full maturity validation
  - Six months Intercalibration with SDO/Extreme Ultraviolet (EUV) Variability Experiment (EVE) and EUV SpectroPhotometer; begin long term trending
  - Six months intercalibration with GOES 12 – 14 EUVS instrument
  - SUVI – EXIS intercalibration
  - Examine 6 months of data for predicable relationships and transfer calibration standard to SUVI

- Performance requirements verification is restricted to the data available
  - Range of solar conditions
  - Solar off-pointing may aid analyses
Summary

• The RIMPs apply System Engineering principles to GOES-R (-16) L1b science data product validation to facilitate Provisional and Fully Validated Maturity
  – Plans were developed for each sensor: ABI, EXIS, GLM, MAG, SEISS, and SUVI
• Product Readiness and Operations (PRO) team implemented these RIMPs in order to address the full scope of Cal/Val activities
  – Required for successful validation demonstration of GEOS-16 L1b data product quality
  – Provides evidence that a given product maturity stage has been reached
• The RIMPs include:
  – Description of every post-launch data product test and required artifacts to demonstrate successful completion of the tests
  – Timing and schedules when each stage is expected to be complete
  – Roles and responsibilities of organizations and personnel
  – Upstream and downstream dependencies and interdependencies
  – Analysis methods and tools to be employed during validation