Building a System-Comprehensive Calibration/Validation Community for NPOESS

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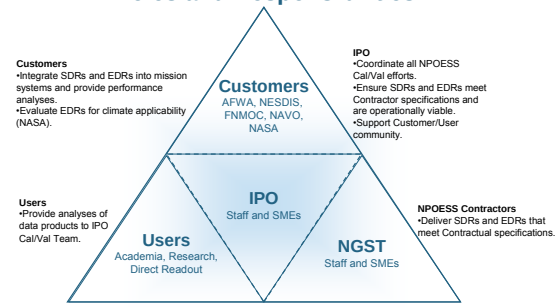
Cal/Val●Calibration/Validation | EDR●Environmental Data Record | IPO●Integrated Program Office | NPOESS●National Polar-orbiting Operational Environmental Satellite System | NPP ● NPOESS Preparatory Project | RDR●Raw Data Record | SDR●Sensor Data Record

IPO Cal/Val Objectives

- **Accomplish the National Mission Capabilities for which the Program was chartered and funded.**
  - **Ensure Product Operational Viability.**
    - Provide the NPOESS Customers with validated, useful data products for their applications.
    - Provide investigations into product defects and inconsistencies of specific impact to Customers.
  - **Provide Independent Verification of NGST results.**
    - Provide technical insight and oversight of NGST Implementation.
    - Provide scientific validation of products.
    - Coordinate issue resolution to meet Program priorities.
- **Facilitate the fullest possible exploitation of the unique data provided from NPP/NPOESS by the science, commerce, climate, and academic communities.**
  - **Support Data Integration for Mission Systems.**
    - Provide Cal/Val beyond basic contractual compliance as required to facilitate acceptability of data products to primary operational systems.
    - Act as liaison between NGST and operational community to coordinate and approve product updates as required.
  - **Support User Community.**
    - Provide general Program information to all users about data products, sensors, and algorithms.
    - Provide technical support to broad research and development community in their assessment and exploitation of NPOESS data.
    - Support NASA and NOAA Climate initiatives by sharing data, software tools, and information.

Community Members Roles and Responsibilities

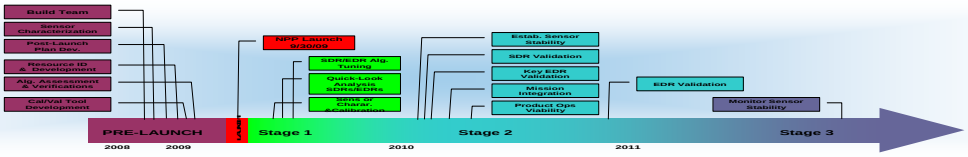


Cal/Val Philosophy

The IPO will lead the extended NPOESS Cal/Val Community by coordinating activities, securing access to and developing Government resources, and sharing Program information, Cal/Val data, and open source tools.

- Sensor performance and characterization are the cornerstone of all data products.
- Experience and resources from past operational and science missions should be fully exploited and incorporated into the NPP and NPOESS Programs.
- Community proficiency with operational algorithms is essential to efficient Cal/Val.
- Space-borne assets, global models, and data assimilation provide a cost effective comprehensive view of sensor and algorithms performances.
- Targeted campaigns and special studies will be planned and executed as needed.
- Customer and User satisfaction is achieved through participation in the Cal/Val process.
- EDR Performance and corrective actions will be handled in accordance with established Program priorities.

IPO Strategy at Each Cal/Val Phase

Cal/Val Phase	RDR	SDR	EDR
Pre-Launch (Present through Launch)	**RDR Development and Verification** •**Question:** What are the criteria that establish sensor as stable, configurable, and useful machine to meet performance requirements? •Verification of Format and Operations •Measurement and Verification of Ambient and Vacuum/Thermal Performance •Adjustment of Parameters •Analyses of Air-to-Vacuum and Temperature Sensitivity •Development of Look-up-tables and Sensor Constants •Training of post-launch sensor team •**IPO Action** •Analyze Sensor Test Data •Archive Sensor Test Data •Assess Test and Engineering Documentation for future reference and understanding •Insure calibration standards met •Establish data format •**SMEs** •VIIRS – MITLL (Fisher), NIST (Rice), GSFC (Xiong), NRL (Lucke) •CrIS/ATMS – USU/SDL (Bingham), UMBC (Strow), MITLL (Blackwell), GSFC (Xiong), NIST (Rice) •OMPS – STAR (Flynn), NRL (Hornsby) •MIS – U.MI (Ruf), U. AL (Spencer), NRL (Poe) •**Data Resources Required** •Sensor test data and documentation from Contractors •Sensor calibration documentation from Contractors	**SDR Development and Verification** •**Question**: Do the SDR Algorithms and Ops Code capture how the sensor actually works, and is this compliant with requirements? •Measurement to Standards •Verification of Completeness of Test Program •Analysis of Error budgets •Analysis & Documentation of Test Data •Development & documentation of Look-up tables •Development & documentation of Sensor constants •Consideration of Fix-or-fly decisions •Preparation of Liens to on-orbit operation concept •**IPO Action** •Analyze algorithms for familiarity •Analyze algorithms for risks •Develop Tuning/Calibration and Validation Strategies •Develop Correction techniques •**SMEs** •VIIRS – UWI/SSEC (Menzel), STAR (Key), GSFC (Lucke) •CrIS/ATMS – STAR (Goldberg, Cao, Key), USU/SDL (Bingham), UMBC (Strow), LaRC (Larar w/Smith), UWI/SSEC (Revercomb) •OMPS – STAR (Flynn), NRL (Hornsby) •MIS – NRL (Poe), UAL (Spencer), UMI (Ruf) •SEM – NGDC (Denig) •**Data Resources Required** •Contractor science and operational algorithms and test data •Heritage algorithms and test data •Airborne sensors (NAST) and under flights of heritage sensors.	**EDR Development and Verification** •**Question**: Are the algorithms stable, tunable, well understood, and working with realistic sensor and system performance characteristics? •Assessment of algorithms and algorithm chains for performance in normal and stressing conditions •Assessment of operational code implementation for performance in normal and stressing conditions •Identification of where more research, added on-orbit resources, post-launch campaigns, or careful watching are needed •**IPO Action** •Analyze algorithm science and operational code for familiarity •Create proxy data •Analyze (science and operational) algorithm performance with proxy data •Compare algorithms with current (heritage) algorithms •Understand how user needs mesh with performance specs •Develop tuning/calibration and validation strategies •Assess resources available and plan for obtaining needed data •**SMEs** •VIIRS – STAR(Key, Ignatov, Heidinger), NAVO(May), U.Miami(Evans, Minnett), NCDC(Privette), UWI/SSEC(Menzel), NRL(Shettle) •CrIS/ATMS – USU/SDL, UMBC(Strow), LaRC(Liu, Larar w/Smith), GSFC(Susskind), STAR(Goldberg, Cao, Reale), UWI/SSEC(Revercomb), •OMPS – NRL(Hornsby), STAR(Flynn) •MIS – UAL(Spencer), NRL(Poe) •SEM – NGDC(Denig) •**Data Resources Required** •Contractor science and operational algorithms and test data •Heritage algorithms and test data •Airborne sensors (NAST) and under flights of heritage sensors •Proxy data generated from heritage sensors •Synthetic data
Post-Launch Stage 1 (Launch through Launch + ~30 Days)	**RDR On-Orbit Verification** ***Sensor Anomaly Resolution*** •**Question**: Is the sensor operating as it was tested? •Analysis of •Engineering data (currents, voltages) •Telemetry data •Calibration data •Adjustment of Instrument Tuning and Parameter •Establishment of baseline for trending •**IPO Action** •Compare sensor performance on-orbit to test performance and resolve issues •Analyze calibration data •Monitor sensor performance over full range of conditions •Apply and refine analysis tools as needed for changes •**Data Resources Required** •Sensor test data and documentation from Contractor(s) •Sensor calibration documentation from Contractors •Engineering, telemetry, and calibration data	**SDR Verification, Tuning, and Initial Validation** ***Sensor and SDR Algorithm Anomaly Resolution*** •**Question**: Are the RDRs and SDR algorithms producing radiances that are reasonable (spectrally and radiometrically) and geolocated? •Comparison of radiance with other space borne assets •Comparison of radiance with model/analysis fields and RTM •Comparison of EDR with products from other space borne assets and model/analysis fields •Performance of calibration maneuvers •**IPO Action** •Compare observed SDRs to expected SDRs (model/analysis fields and RTM) •Compare SDRs to data from other space borne assets •Monitor SDRs to Monitor Tuning/Calibration and Validation tasks performed by NGST? •Adjust models based on calibrationtuning changes •Refine correction techniques •**Data Resources Required** •Contractor operational algorithms and SDRs •Data from similar space borne assets •Airborne sensors (NAST) and under flights of sensors	**EDR Verification and Initial Validation** ***Sensor, SDR and EDR Algorithm Anomaly Resolution*** •**Question:** Are the EDR algorithms functioning and valid over a subset of conditions? •Verification of all sensor input availability •Activation/Training of EDR Algorithms •Comparison of EDRs with products from other space borne assets and model/analysis fields •Identification of large scale patterns •Analysis of selected conditions •Sensor operating range •Stressing environmental •Generation of matchups with leveraged data sets (buoys, sondes, etc.) •Collection of RDR, SDR, EDR, Cal & Engineering Data •**IPO Action** •Analyze output of all EDRs in priority order for completeness and validity •Compare EDRs with other space borne assets •Compare EDRs with matchup data sets •Begin to Analyze and resolve anomalies •Adjust algorithms based on sensor calibration data •Tune algorithms by generating appropriate coefficients and LUTs •**Data Resources Required** •Contractor operational algorithms and EDRs •Data from similar space borne assets •Airborne sensors (NAST) and under flights of sensors
Post-Launch Stage 2 (Launch + ~30 Days through Launch+6-18 Months)	**Establish Sensor Stability** ***Sensor Anomaly Resolution*** ***Modification of Operations Concepts*** •**Question**: Is the sensor and its calibration stable of the sensor range of operating conditions? •Analysis of detailed telemetry and calibration data •Analysis of trend and correlation data •**IPO Action** •Analyze detailed telemetry and calibration data for trends •Monitor to verify trends and causes of anomalies so they can be anticipated or resolved quickly •**Data Resources Required** •Sensor test data and documentation from Contractors •Sensor calibration documentation from Contractors •Engineering, telemetry, and calibration data	**SDR Validation** ***Sensor and SDR Algorithm Anomaly Resolution*** •**Question**: Are the SDRs precisely geolocated, stable, and valid to expected levels (accuracy and precision) over conditions to date? •Analysis of accumulated comparisons with radiances from other space borne sensors and model fields •Zonal average global sense •Performance of Statistical analysis (vicarious calibration) •Assimilation of Radiances (non-operational) •Analysis of accumulated comparisons with EDRs from other space borne sensors and model fields •Zonal average global sense •Performance of calibration maneuvers •Execution of possible under flights •**IPO Action** •Coordinate under flights for SDR validation •Continue to Compare SDRs to data from other space borne assets •Monitor SDRs to Monitor Tuning/Calibration and Validation tasks performed by NGST? •Continue to monitor performance over all conditions to identify problem areas •Resolve issues in calibration or performance using knowledge of sensor •Validate performance of models using SDRs as input •Collect and coordinate all known information from all teams, Government and NGST/Raytheon •**Data Resources Required** •Contractor operational algorithms and SDRs •Data from similar space borne assets •Airborne sensors (NAST) and under flights of sensors	**EDR Validation** ***EDR Algorithm Anomaly Resolution*** ***EDR Algorithm Tuning*** •**Question**: Are the EDR algorithms functioning over a broad range of conditions, operationally viable and consistent with heritage products? •EDR Activation/Training •Analysis of accumulated comparisons with EDRs from other space borne sensors and model fields •Zonal average global sense •Residuals analysis •Analysis of accumulated matchups with leveraged data sets (buoys, sondes, etc.) •Collect RDR, SDR, EDR, Cal & Engineering Data •Establishment of reference data sets (golden days) •**IPO Action** •Continue to Compare EDRs with other space borne assets •Continue to Compare EDRs with matchup data sets •Resolve anomalies/performance issues with key EDRs, then lower priority EDRs •Tune algorithms and establish values for threshold parameters •Monitor EDR performance over all conditions to establish trends •Validate EDR performance in known extreme conditions and events, such as dust storms •Collect and coordinate all known information from all teams, Government and NGST/Raytheon •Coordinate field campaigns to cover performance of several EDRs •**Data Resources Required** •Contractor operational algorithms and EDRs •Data from similar space borne assets •Airborne sensors (NAST) and under flights of sensors •Buoy, sonde, ...etc data
Post-Launch Stage 3 (Launch + ~18 Month through Sensor Lifetime)	**Sensor Long-Term Monitoring** ***Sensor Anomaly Resolution*** ***Modification of Operations Concepts*** •**Question**: Is the sensor stable over seasons and is degradation as expected? •Continued Trending and Analysis of engineering data, telemetry data, and calibration data •Tuning of warning thresholds •**IPO Action** •Continue to analyze detailed telemetry and calibration data for trends and deviation from known trends •Monitor to verify trends and causes of anomalies so they can be anticipated or resolved quickly •Validate warning thresholds •**Data Resources Required** •Sensor test data and documentation from Contractors •Sensor calibration documentation from Contractors •Engineering, telemetry, and calibration data	**SDR Detailed Validation and Maintenance** ***Sensor and SDR Algorithm Anomaly Resolution*** •**Question**: Are the SDR algorithms and supporting LUTs and sensor constants optimized as the sensor ages? •Tracking of radiance performance •Handling of "state changes" •Handling of A/B side •Handling of Channel Loss •Handling of Degradation of electronics •Handling of Degradation of calibration targets •Handling of Degradation of optics •**IPO Action** •Continue to Compare SDRs to data from other space borne assets •Monitor SDRs to Monitor Tuning/Calibration and Validation tasks performed by NGST? •Continue to monitor performance over all conditions to identify problem areas •Resolve issues in calibration or performance using knowledge of sensor •Validate performance of models using SDRs as input •Collect and coordinate all known information from all teams, Government and NGST/Raytheon •**Data Resources Required** •Contractor operational algorithms and SDRs •Data from similar space borne assets •Airborne sensors (NAST) and under flights of sensors	**EDR Detailed Validation and Correction** ***EDR Algorithm Anomaly Resolution*** ***EDR Algorithm Rework & Tuning*** •**Question**: Are the EDR products valid over the full range of conditions and operationally viable? •Analysis of accumulated comparisons with EDRs from other space borne sensors and model fields •Validation in stressing and important conditions •Residuals analysis •Analysis of accumulated matchups with leveraged data sets (buoys, sondes, etc.) •Validation in stressing and important conditions •Residuals analysis •Tuning and analysis with reference data sets (golden days) •EDR-driven campaigns for poorly understood conditions, as needed and prioritized •Adapting to channel loss, sensor degradation •**IPO Action** •Resolve anomalies/performance issues with key EDRs, then lower priority EDRs •Rework/refine algorithms not meeting performance requirements •Improve priority algorithms for best performance possible, followed by lesser priority EDRs to obtain maximum performance •Validate EDR performance in known extreme conditions and events, such as dust storms •Collect and coordinate all known information from all teams, Government and NGST/Raytheon •**Data Resources Required** •Contractor operational algorithms and EDRs •Data from similar space borne assets •Airborne sensors (NAST) and under flights of sensors •Buoy, sonde, ...etc data

Nominal NPP Cal/Val Timeline