Status Overview of JPSS VIIRS Testing

K. Thome[1], J. Xiong[1], H. Oudrari[2], and J. McIntire[2]

[1]NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

[2]Science Systems and Applications Inc., Lanham, MD 20760, USA

Acknowledgements:

VIIRS Characterization Support Team (VCST)

NASA VIIRS On-site Instrument Team

Talk overview

Provide the context for the detailed talks to follow

- Follow-up to the previous talk from the government perspective
- What you should get from this talk
  - J1 VIIRS is not identical to NPP VIIRS
  - Government/Raytheon partnership has provided a J1 VIIRS that will prove to be a worthy follow-on sensor
- Outline
  - J1 VIIRS testing overview
  - Overall Sensor Performance Assessment
  - Waivers – why and what
  - What next

Pre-launch testing objectives

Characterize overall performance and identify potential noncompliance issues

- Testing includes radiometric, geometric, and spectral performance
- Ensure sensor performance meets its design requirements
- Check that sensor data quality is adequate to achieve overall science objectives
- Allows key sensor performance parameters to be derived for on-orbit operation and calibration
- Support implementation of potential mitigation strategies designed to address noncompliance issues

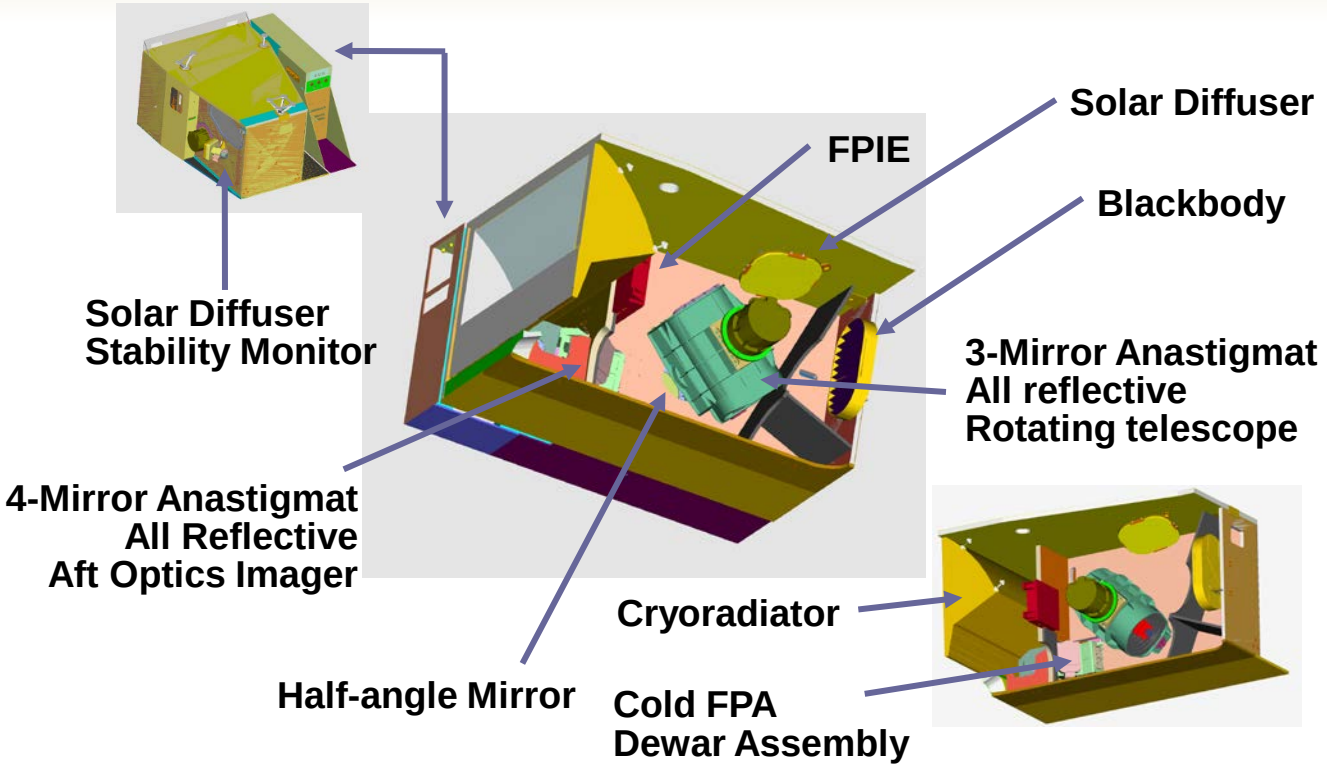
Pre-launch testing phases

Three major phases in pre-launch

- Component and Sub-system Level Testing
- Sensor Level Testing
  - Ambient
  - Pre-TVAC
  - TVAC
  - Post-TVAC
- Observatory Level Testing

Pre-launch testing overview

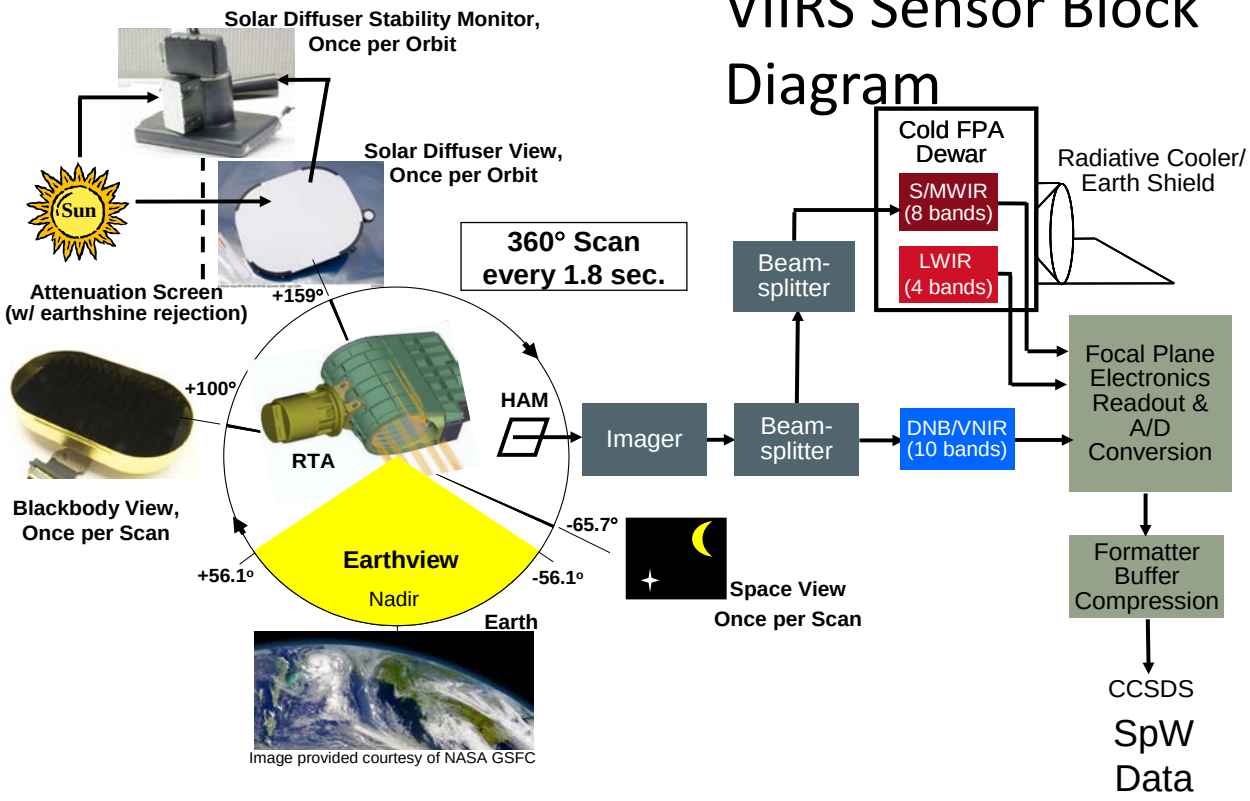
Complicated sensor such as VIIRS leads to a long list of tests



- Radiometric
  - SNR/NEdT, detector gains and dynamic range
- Spectral
  - In-band and out-of-band relative response
- Spatial and geometric
  - Band-to-band registration, modulation transfer function, and pointing

Prelaunch testing overview

Tests also included evaluation of the full system including onboard calibrators



- Thermal testing
- Electromagnetic interference
- Response versus scan-angle
- Solar diffuser and diffuser monitor screen transmission function
- Vibration testing
- Polarization sensitivity
- Blackbody emissivity
- Solar diffuser BRDF
- Stray light

Assessing sensor performance

Test data evaluated by sensor vendor (Raytheon SAS) and government teams

- Independent assessments as well as collaborative
- Government Team
  - Aerospace Corp.
  - U. of Wisconsin
  - NASA
  - NOAA
- Periodic reviews
  - Data Review Boards to evaluate results presented by sensor team
  - Data Analysis Working Group to evaluate results primarily from government team
  - Special technical interchange meetings
  - Regular briefing at NOAA VIIRS SDR meetings

Data Analysis Working Group

DAWG's sharing of J1 test finding with science community deserves a bit more attention

- Analysts from a range of government-funded organizations
- Provided independent examination of the J1 instrument test data
- Shared performance results and issues
  - NOAA and NASA subject matter experts (SMEs) for SDRs and EDRs
  - JPSS Project Science Office
  - Instrument vendor, Raytheon
- Gave early information on areas of J1 performance noncompliances

Overall results summary

Component, subsystem, and sensor level test results indicate J1 VIIRS data can meet our science objectives

- J1 and NPP VIIRS are not identical – good and not so good
- 15 waivers were approved prior to J1 shipment to the spacecraft vendor
- Items identified as key drivers for science:
  - SWIR nonlinearity at low light levels
  - Emissive band striping (noisy detectors, which do not require a waiver, impact this as well as detector to detector variability in RSR)
  - Dynamic Range (and rollover)
  - Near Field Response
- Issues found with J1 VIIRS are correctable with mitigation plans or will lead to acceptable impact

NPP versus J1

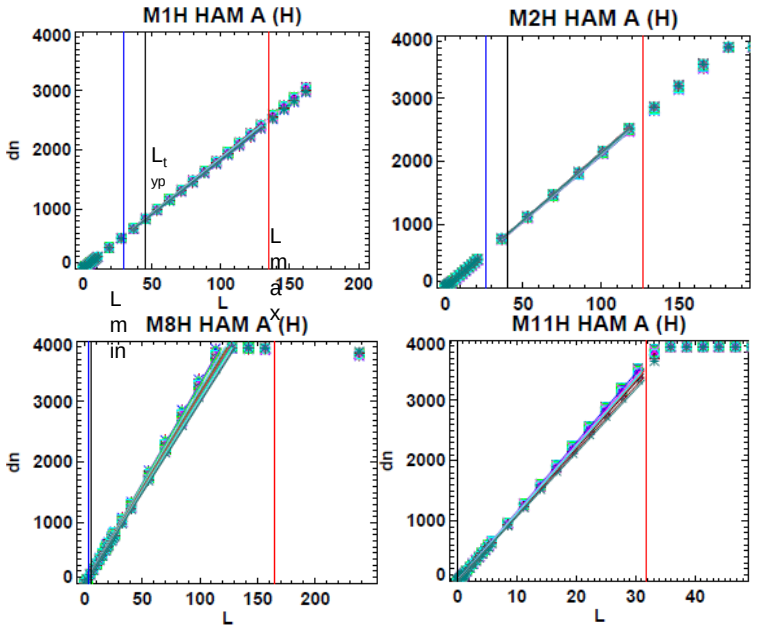
No two identical sensors behave identically as we learned from Landsat TM and MODIS

- Design changes between NPP and J1 VIIRS and build-to-build variations led to performance differences
- Optical changes made to coatings of RTA mirrors and dichroic give J1 better spatial stability
- Exposure of mirrors to tungsten was eliminated which should improve J1 SNR over sensor lifetime
- VisNIR Integrated Filter Coating changes were made
  - Reduced crosstalk and out-of-band light giving better defined relative spectral response
  - *Increased polarization sensitivity in Bands M1-M4*
- DNB and SWIR non-linearities are seen at low radiance for J1

RSB Radiometric Performance

Meeting nearly all requirements for SNR, dynamic range, and gain transition

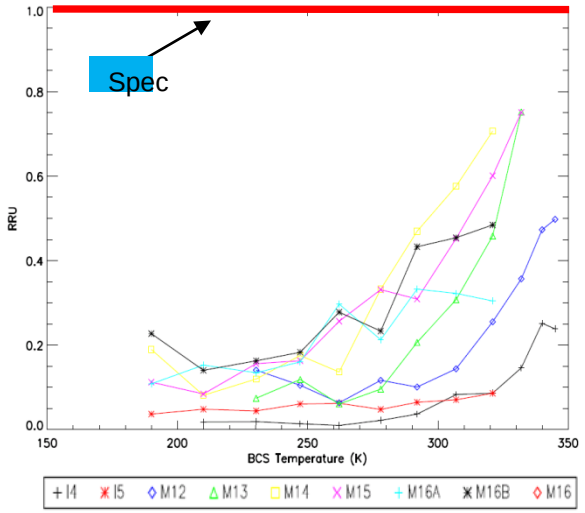
- **As good as S-NPP**
- Minor non-compliances for dynamic range
  - M8 (72%) and I3 (91%)
  - I3 Det4 is a bad detector (very noisy and lower responsivity)
- Shortwave bands non-linearity
  - High residuals at low radiance
  - Issue can be mitigated using higher order calibration equation
- DNB HGS/MGS non-linearity
  - Shown only at higher aggregation modes (22-32)
  - Altering aggregation approach can mitigate this



TEB Radiometric Performance

Meeting all requirements for NEdT, Dynamic Range, and non-linearity

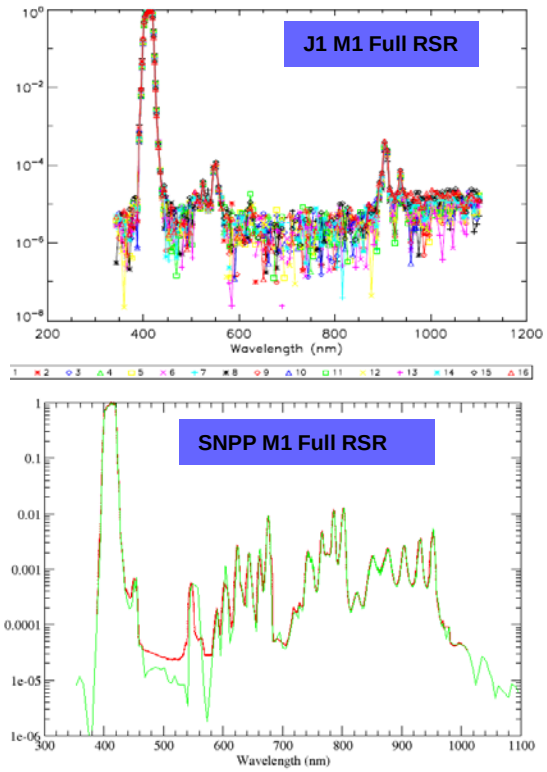
- Minor noncompliance issues include M12 not meeting the absolute radiometric calibration (ARD) at low temperature
  - Similar to SNPP
  - J1 also did not meet the characterization uncertainty for many bands
- Out of family detectors (higher noise) were identified
  - M16B D5 and M15 D4, are considered as low risk
  - Could result into striping in products such as SST



Sensor Spectral and Spatial Performance

J1 spectral performance is generally better than SNPP

- J1 RSRs Version 0 (V0) was released on 02/26/2015 by DAWG team with Version 1 (V1) in June 2015
- Future releases with TSIRCUS are also planned
- Electrical and optical crosstalk generated from spectral testing is comparable to SNPP performance
- No significant crosstalk effect has been seen to this point with S-NPP on-orbit data
- Spatial performance is overperforming on J1
- Band-to-band registration differences are now larger in track as opposed to cross-track



Waivers – why and what

Analysis of results showed several noncompliances that required waivers

- Ideally, sensor would meet all requirements
- Complexity of VIIRS sensor makes it difficult to achieve full compliance for all requirements at the same time
- The following options were essentially available to correct a non-compliance on J1
  - **Option 1:** Accept a waiver for use of J1 as is
  - **Option 2:** Change the requirement to encompass the existing performance for J1 and likely J2
  - **Option 3:** Hardware changes

J1 waivers handled through group effort

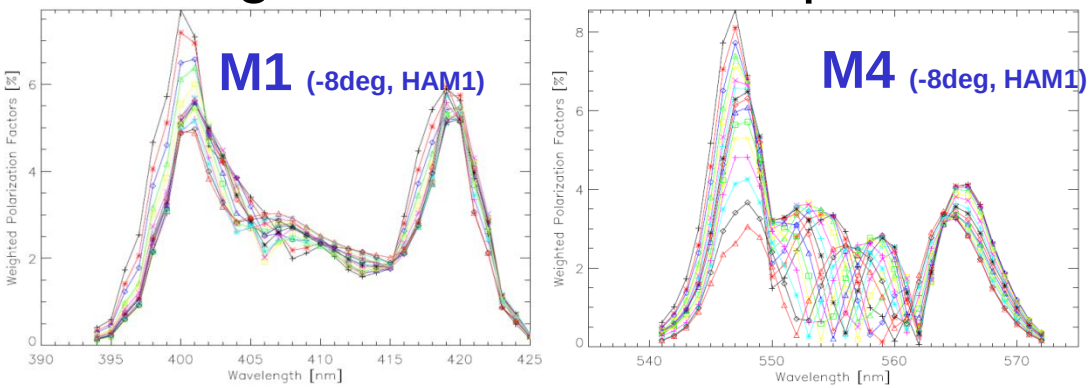
J1 waivers could be viewed as a success, at least from an analysis standpoint

- Waiver Working Group was formed to evaluate the options for each waiver
- Formal process because requirements are contractual
  - Some are more important than others
  - Process attempts to ensure government spends its dollars on the non-trivial waivers
- Schedule was not favorable
  - Pre-ship review originally scheduled for mid-January 2015
  - Formal discussions of the Waiver Working Group began mid-November
- J1 Science community evaluated the waivers and proposed recommended options for each prior to the end of 2014

Waivers were not just accepted - no, really

Additional testing was recommended in several cases

- Added polarization testing provided data needed to implement an on-orbit polarization correction
  - Extension of original Raytheon tests
  - Inclusion of NIST's traveling laser-based source (TSIRCUS)
- Added tests to evaluate alternate approaches for operating the DNB to mitigate non-linearity
- TSIRCUS testing of ocean color spectral response



Waiver summary

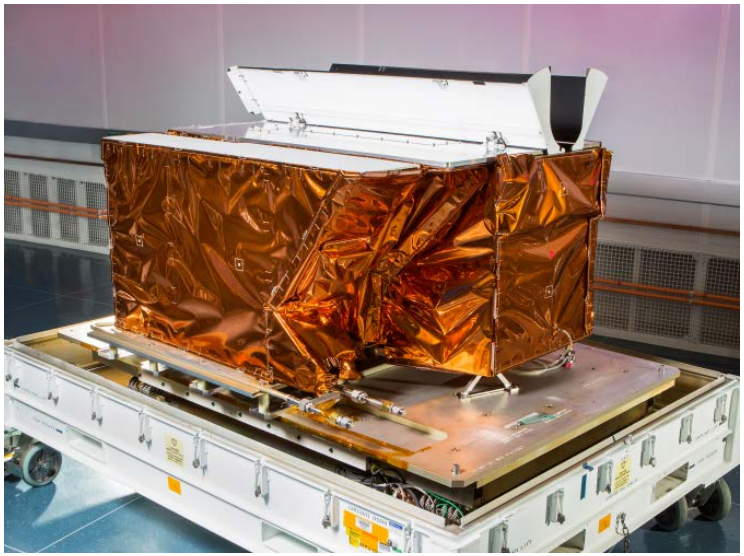
- **Polarization sensitivity** – TSIRCUS and broadband results consistent and point to an on-orbit mitigation
- **RSR** - consistent with S-NPP and no major impacts to EDRs expected
- **Emissive bands** – similar behavior to S-NPP
- **BBR** – noncompliance from in-track direction, not scan
- **RSB - SWIR non-linearity -**Cubic equation to enhance radiometric performance
- **Spatial resolution** – waivered on the "better" side
- **Crosstalk -**J1 is better than S-NPP
- **DNB straylight** – additional testing was performed
- **DNB non-linearity** – additional testing was performed
- **Near-field response –** primarily due to conservative assessments regarding causes of optical scatter
- **Lmax -** Similar behavior as S-NPP but a bit worse from better optical performance of J1

Way forward

J1 Sensor (Shipped Feb 5th, 2015)

- Another round of testing early in 2016
- Another round of telecons and reviews as well
- Present the results at next year's meeting

Raytheon/NASA Team – Sensor Shipping from RTN



VIIRS J1 installation on the Spacecraft