NPP/VIIRS: Status

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Project Scientists

Contributions from:

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Government VIIRS Data Analysis Working Group

NASA, NOAA/IPO, Aerospace, MIT/Lincoln, Wisconsin

37 members, 20 NASA, 13 Aerospace, 4 MIT LL

(29 East Coast, 6 West Coast, 2 Wisconsin)

Launch Date: October 25, 2011

When we last met:
VIIRS in Clean Room with NPP
No CrIS


Current Status:
NPP Completed
Environmental Testing

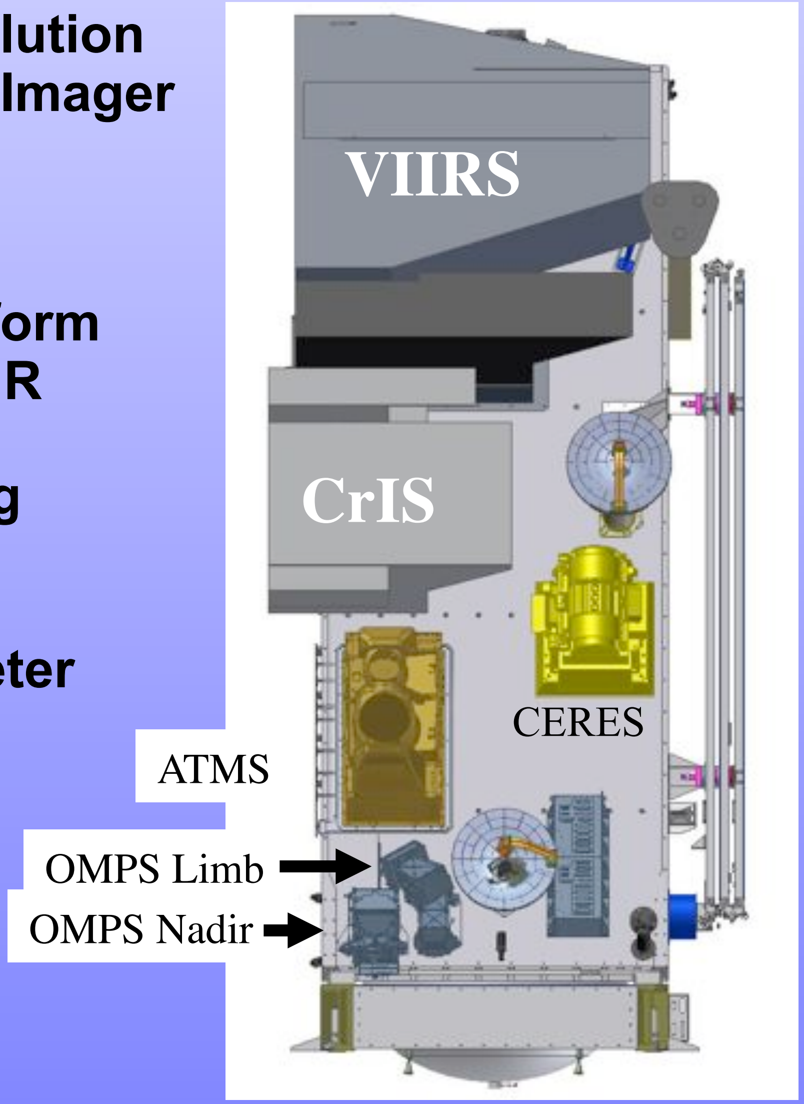
NPP Status:

VIIRS – Medium resolution Visible& Infra-red Imager

CrIS – Fourier Transform Spectrometer for IR Temperature and Moisture sounding

ATMS – Microwave sounding radiometer

OMPS – Total Ozone Mapping and Ozone Profile measurements



CERES Earth Radiation Budget measurements

Completed Environmental Testing; Shock, Acoustics, Vibration, EMI/EMC, Thermal Vacuum

Visible Infrared Imaging Radiometer Suite

Description

- **Purpose:** Global observations of land, ocean, & atmosphere parameters at high temporal resolution (~ daily)
- **Predecessor Instruments:** AVHRR, OLS, MODIS, SeaWiFS
- **Approach:** Multi-spectral scanning radiometer (22 bands between 0.4 µm and 12 µm) 12-bit quantization
- **Swath width:** 3000 km

Status

- Completed comprehensive performance monitoring testing during TV testing.
- Performance is nominal
- Preparing for Launch

Status of VIIRS F1 Performance Testing

- **VIIRS F1 testing program completed all planned testing phases, and has provided test data to support 141 sensor performance requirements:**

VIIRS Testing Phases	
Ambient Testing Complete:	06/20/07 – 11/30/07
Sensor TVAC Testing Complete:	05/03/09 – 08/23/09
Spacecraft TVAC Testing Complete:	03/10/11 – 04/25/11

- **NASA team has completed extensive test data analysis and VIIRS F1 performance requirement verification:**
  - VIIRS testing program was comprehensive and provided necessary test data to characterize VIIRS performance, and to establish a good baseline for on-orbit operations.

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- **All performance waivers have been evaluated by NGST and reviewed by NASA team**
  - Most waivers have small to negligible EDR performance impacts
  - Algorithm revisions and/or changes to Cal/Val tasks were added to support waivers

VIIRS F1 Reflective Bands: Radiometric Performance

Meets all Requirements for:

Signal to Noise Ratio, Dynamic Range, Linearity, Uncertainty, Stability and Polarization

Minor Variances for:

Gain Transition: Gain transition points are well characterized (VIIRS has dual gain bands)

Uniformity: Potential for striping, Plan for post-launch fix if needed

VIIRS F1 Emissive Bands: Radiometric Performance

Meets all Requirements for:

NEdT, Dynamic Range, Gain Transition, Linearity, Uniformity, Absolute Radiometric Difference, and Stability

VIIRS F1 Spatial Performance

Meets Requirements for or only minor non-compliances:

Line Spread Function:

- **Scan and Track DFOV**
- **Scan and Track MTF**
- **Scan and Track HSR**

Band-to-Band Registration

Pixel growth to "1.5 km x 1.5 km" at to the edge of scan

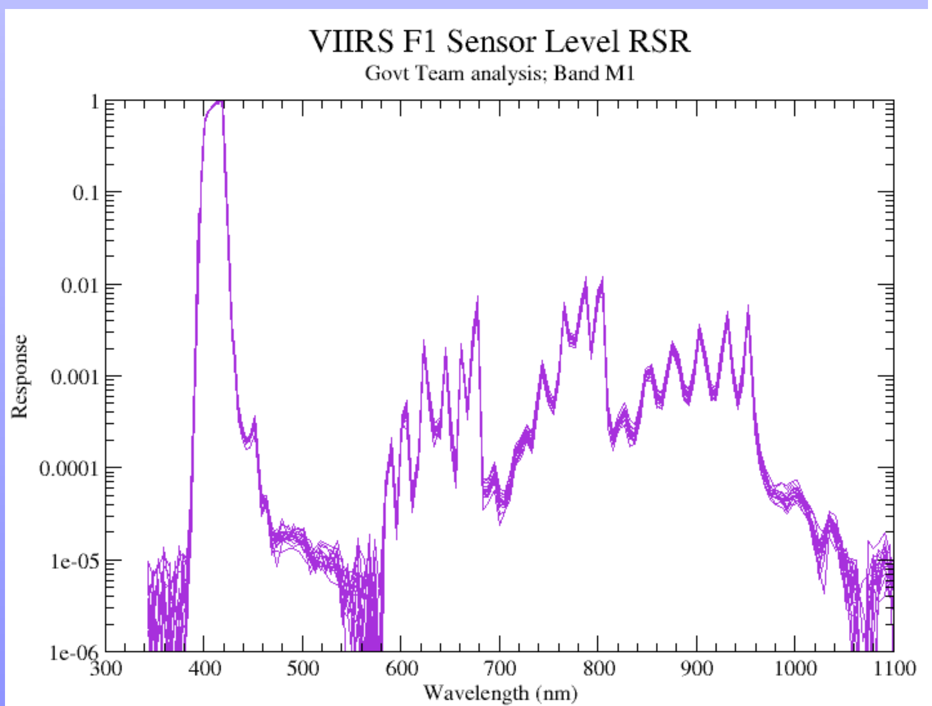
VIIRS F1 Spectral Performance

- **Largely Meets all Requirements for:**
  - Spectral Band Center, Spectral Bandwidth, Extended Bandwidth
  - Minor non-compliances are well characterized. No impact expected.
- **Non-Compliances for Integrated Out-of-Band (OOB) Response**
  - Many bands did not meant the IOOB requirements, but low impact
  - Multiple spectral testing provided a reliable F1 IOOB characterization
- **Spectral Band-to-Band Crosstalk**
  - VIIRS did not meet crosstalk requirements, which are much more strict than heritage values (e.g. MODIS)
  - Optical cross-talk issue is well known (IFA defects), and intensively studied by both contractor and Government teams, using characterization data from testing performed at IFA and sensor levels.
  - Impact analysis has shown Ocean and Aerosol EDRs products sensitive to this crosstalk effect. A mitigation plan was established for on-orbit operations in the case of these 2 EDRs.

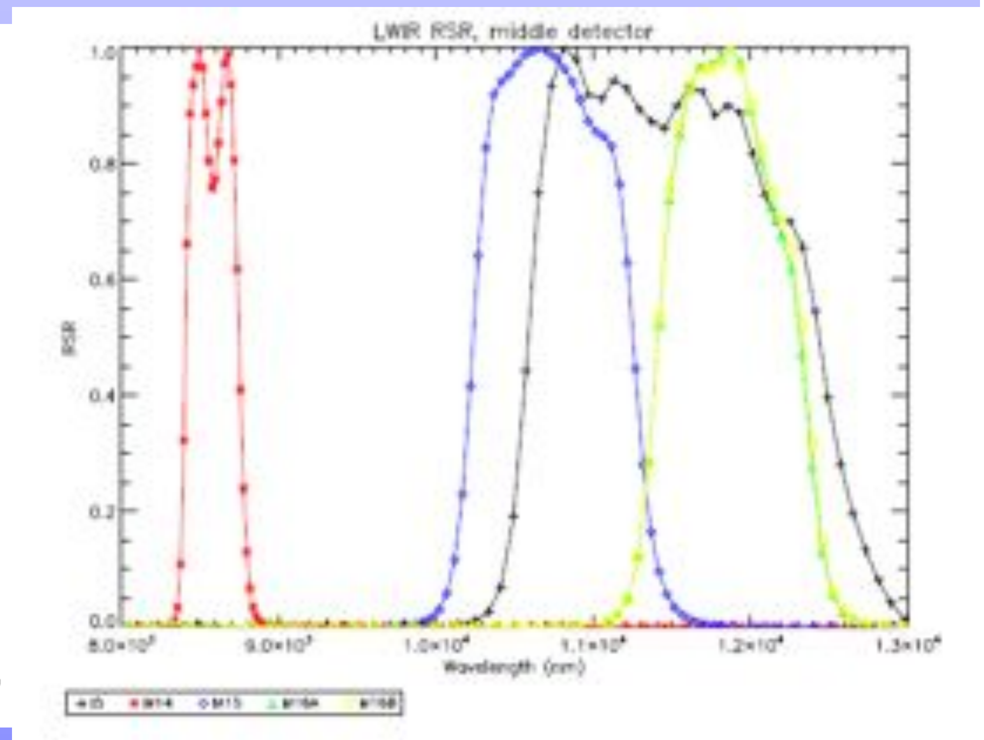
Government Team's VIIRS RSRs

Reflective and Emissive Bands

VIIRS M1 Band



VIIRS LWIR Bands



Testing Summary

- VIIRS F1 test program is complete and has provided good test data to assess sensor performance.
- All F1 sensor performances has been verified, and non-compliances are expected to have minor effect on NASA science.
- Effort by both Government and Contractor finalized sensor performance to generate VIIRS F1 on-orbit LUTs for SDR algorithm.
- VIIRS measured performance, supported by planned calibration and validation activities is expected to meet NASA science objectives

Maneuvers

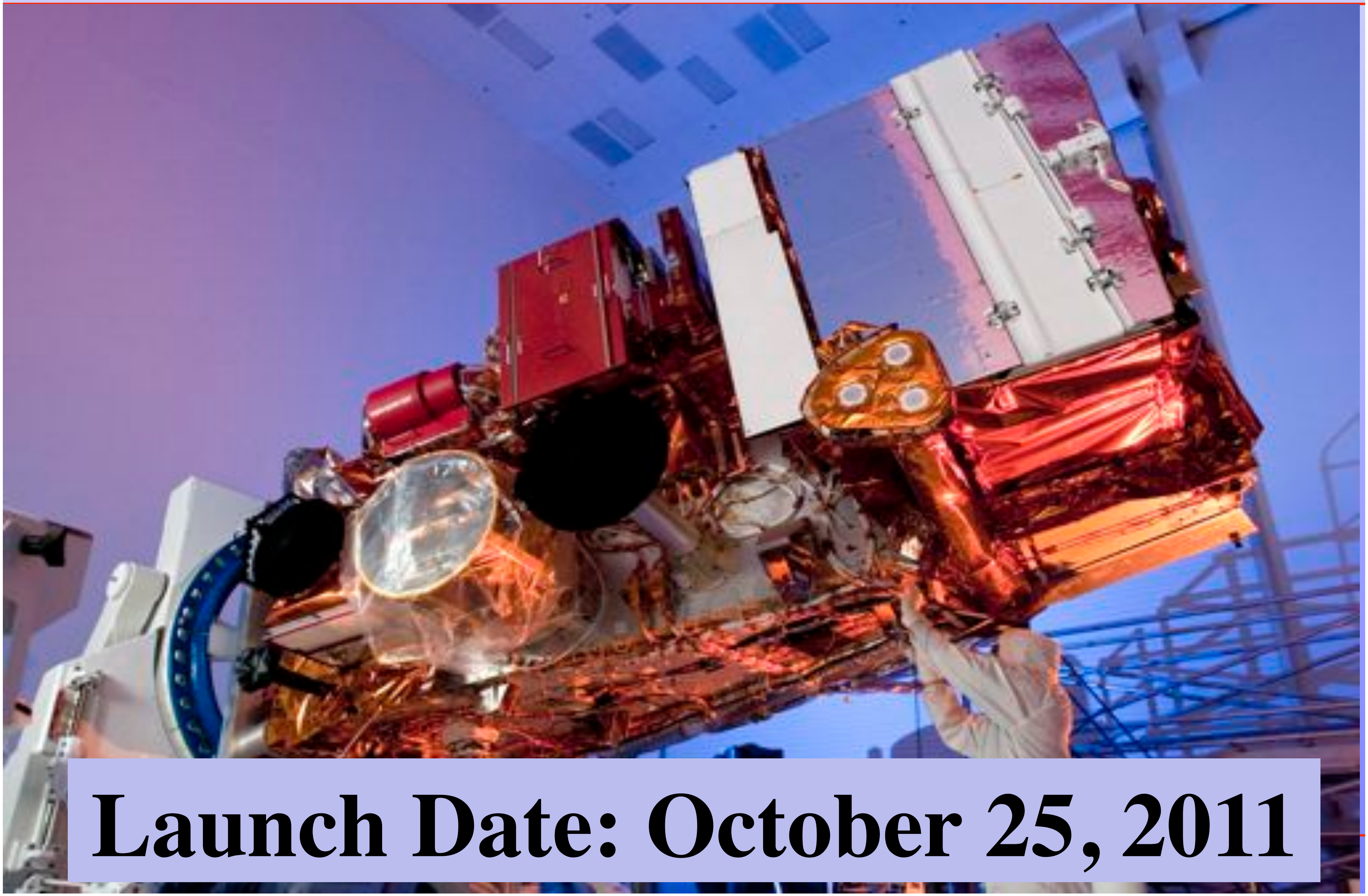
- All VIIRS maneuvers have been approved by NPP Project
  - Lunar Rolls and Pitch-up for deep space view and Yaws for diffuser characterization
  - Maneuvers will be done during Intensive Cal/Val
  - Working with NOAA and JPSS to ensure maneuvers part of regular operating baseline

JPSS

- JPSS Transition is ongoing
  - FY10 & FY11 (& FY12??) budgets are a challenge

- Government taking responsibility for IDPS Data Product Performance
  - NOAA NESDIS STAR providing leadership for VIIRS data products
    - Changyong Cao for VIIRS SDR
    - Ivan Csiszar for VIIRS EDRs
  - Existing Gov't funded cal/val activities are continuing.

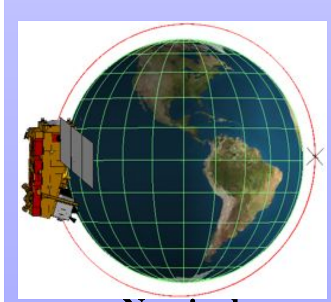
Questions



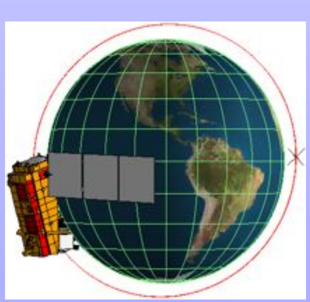
Launch Date: October 25, 2011

Maneuver #1 – Roll -25 degrees

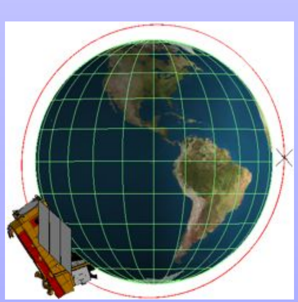
- Roll Maneuver (-X) - up to –25 degrees on the dark side of the orbit, and maintaining the offset for up to 5 minutes.
- Spacecraft baseline requirement : YES



Nominal



Roll -25º



Nominal

Science Rationale / Benefit

Meets needs of VIIRS Lunar Roll maneuver #8

ADCS / Thermal Assessment

Reference : SER 3257-THR248 (Thermal model V72)

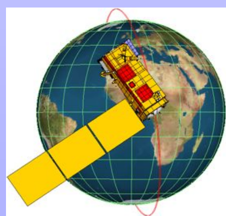
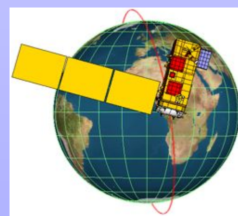
SRS analysis accesses compliance to all thermal requirements of all spacecraft components and instrument interfaces throughout these maneuvers for Nominal Operation Science Mode (instruments powered on with doors open) as well as SRS Commissioning Maneuver Checkout (instruments powered off with doors closed). Eight individual hot and cold cases for bounding beta angles 12º and 34º were run; four in each mode.

Summary

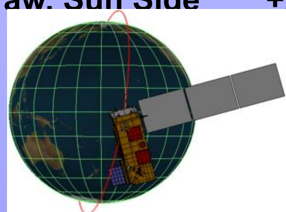
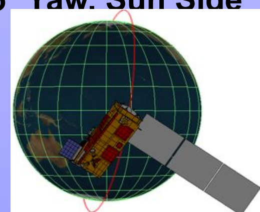
- As part of spacecraft ADCS commissioning, BATC will demonstrate this maneuver
- SRS Compliance if performed in eclipse, S/C –Y side toward earth
- Orientation modeled and all thermal parameters within allowable limits based on analysis

Maneuver #2 – Yaw +/-25 degrees

- <u>Yaw Maneuver (+/-Z)</u> : yaw offset pointing up to 25 degrees, and maintaining the offset for up to 15 minutes at any point in the orbit.
- <u>Spacecraft baseline requirement</u> : YES

- -25º Yaw, Sun Side   +25º Yaw, Sun Side

-25º Yaw, Eclipse Side   +25º Yaw, Eclipse Side

<u>Science Rationale / Benefit</u>

Meets needs of VIIRS Solar Diffuser Cal maneuver #9

Meets needs of CERES Sunrise Solar Calibration maneuver #9 and Sunset Solar Calibration maneuver #10

<u>ADCS / Thermal Assessment</u>

Reference : SER 3257-THR248 (Thermal model V72)

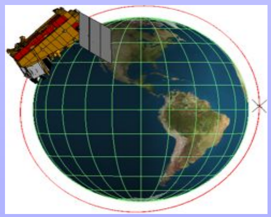
SRS analysis accesses compliance to all thermal requirements of all spacecraft components and instrument interfaces throughout these maneuvers for Nominal Operation Science Mode (instruments powered on with doors open) as well as SRS Commissioning Maneuver Checkout (instruments powered off with doors closed). Thirty-two individual subsolar and eclipse, hot and cold cases for beta angles 12º & 34º, at +25º and -25º, were run. Sixteen cases for each mode

<u>Summary</u>

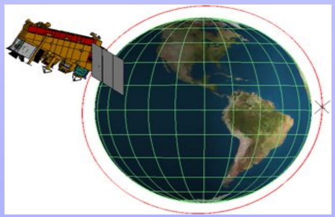
- As part of spacecraft ADCS commissioning, BATC will demonstrate this maneuver
- SRS Compliance to demonstrate yaw out to +25 deg, occurs in eclipse and daylight
- SRS Compliance to demonstrate yaw out to -25 deg, occurs in eclipse and daylight
- Orientation modeled and all thermal parameters within allowable limits based on analysis

Maneuver #3 – Pitch Over Maneuver

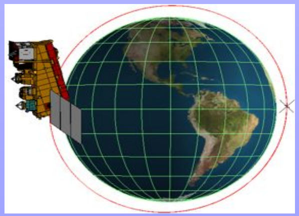
- **Pitch Over - +Y slew in the opposite direction of the orbital pitch rate over 1/3 of the orbit, starting at terminator crossing from the Science Mode attitude, at the lowest constant rate that will return the Spacecraft to nominal pointing at the end of the slew**
- **Spacecraft baseline requirement : YES**



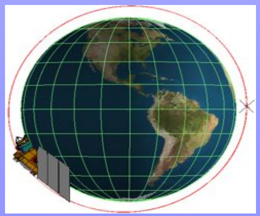
Nominal, Dusk Terminator



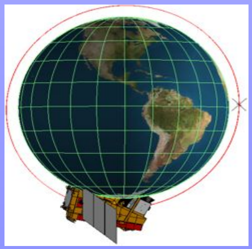
Pitch 90º



Pitch 180º



Pitch 270º



Nominal, Dawn Terminator

Science Rationale / Benefit

Meets VIIRS, ATMS and CERES needs for view of deep space maneuver #6

ADCS / Thermal Assessment

Reference : SER 3257-THR248 (Thermal model V72)

SRS analysis accesses compliance to all thermal requirements of all spacecraft components and instrument interfaces throughout these maneuvers for Nominal Operation Science Mode (instruments powered on with doors open) as well as SRS Commissioning Maneuver Checkout (instruments powered off with doors closed). Eight individual hot and cold cases for beta angles 12º & 34º were run. Four cases for each mode

Summary

- **As part of spacecraft ADCS commissioning, BATC will demonstrate this maneuver**
- **SRS Compliance to demonstrate one back flip in eclipse,**
- **Orientation modeled and all thermal parameters within allowable limits based on analysis**

Maneuver #6 – Pitch Maneuver

- VIIRS, CERES, ATMS Pitch Maneuver (+Y) : slew in the opposite direction of the orbital pitch rate over 1/3 of the orbit, starting at terminator crossing from the Science Mode attitude, at the lowest constant rate that will return the Spacecraft to nominal pointing at the end of the slew
- Spacecraft baseline requirement : Yes

Science Rationale / Benefit

Frequency/Dwell : Twice separate by 1 orbit in the absence of the moon

Heritage : NOAA 14 at EOL; Terra after 2 years

Science Improvement :

- VIIRS 0.5-1% Asymmetry correction
- ATMS 1-3% Scan Bias Correction due to side lobe contributions based on both ATMS rolls (#4/#5) and the pitch over maneuver (#6)
- CERES Reduces Offset uncertainty from 50 to 12 % (4:1)

ADCS / Thermal Assessment

ADCS Reference: SER 3257-ACS339

Thermal Reference : SER 3257-THR250

All bus components and instrument interfaces are compliant and within their flight allowable limits throughout each of calibration maneuvers with instruments powered on and doors open.

Prior to the pitch maneuver, the spacecraft remained in its nominal science mode orbit. Four individual hot and cold cases for beta angles 12º & 34º were run, where instruments are powered on with doors open.

Summary

- **This maneuver was accepted but will be limited to only one pitch maneuver. It will be performed between L+3 and L+6 months post launch. A revised thermal analysis is a prerequisite using on orbit thermal data.**
- **Extended view of deep space for the calibration of potential scan asymmetry. Same as VIIRS and CERES Pitch maneuvers, hence only one consolidated maneuver is needed, but simulated twice, separated by one orbit (as required for ATMS).**
- **Risk of VIIRS / CrIS cryo temperatures rise above set points or reverse bias on VIIRS cooler stages for low beta angles. Possible loss of emissive band**

VIIRS Performance Evaluation based on Spacecraft TVAC Testing

- NASA/NICST team provided an independent verification of the VIIRS performance measured during NPP TVAC testing.
- NASA/NICST team received and processed all four VIIRS CPT test data, from Cold-1, Hot-1, Cold-4 and Hot-4 plateaus. CPT testing included:

VIIRS Performance Evaluation based on Spacecraft TVAC Testing		
Performance	**Description**	**Risk**
Gain and SNR	FPI source is used to illuminate VIIRS sensor inside the TVAC chamber at Ball. Gain values derived for VIIRS bands are within 10% of sensor level gains. SNR meet specification, but lower than sensor level testing (Source issue).	Low
OBC Warm-up/Cool-down	OBC operations meet spec for range and uniformity. Gain within 1.2% of sensor level testing	Low
Electronics Self-Test	In agreement with sensor level testing	Low
Noise	In agreement with sensor level testing	Low
SDSM Checkout	SDSM functionality verified (mirro rotating normally)	Low
Trending of gain and noise	No anomalies observed during the self compatibility testing	Low

- NASA/NICST team released about seventeen (17) reports and summaries over 43 days of VIIRS TVAC testing, describing preliminary results of the test data analysis.
- NASA/NICST verified that VIIRS data collected and analyzed are of good quality and sufficient to verify sensor performance.
- NASA/NICST team summaries are in agreement with the contractor's findings, that the sensor performance is as expected, and no specific concern or issue was identified

VIIRS F1 Band-to-Band Registration Performance

Worst BBR @ Nominal Perf Plateau

|<----Worst BBR = Minimum(12 or 24 DDR (detector-to-detector co-registration) pairs for HAM A and B sides) ---->|

Band	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16A	M16B	I1	I2	I3	I4	I5
M1		0.96	0.95	0.97	0.89	0.87	0.91	0.84	0.83	0.95	0.81	0.89	0.90	0.86	0.90	0.92	0.90	0.94	0.93	0.91	0.93	0.89
M2	0		0.95	0.97	0.89	0.87	0.91	0.84	0.83	0.95	0.81	0.92	0.92	0.86	0.89	0.92	0.90	0.94	0.93	0.91	0.93	0.89
M3	0	0		0.98	0.94	0.91	0.96	0.89	0.87	0.96	0.85	0.89	0.90	0.91	0.94	0.95	0.94	0.99	0.97	0.95	0.97	0.94
M4	0	0	0		0.92	0.9	0.94	0.87	0.86	0.97	0.84	0.89	0.90	0.89	0.92	0.95	0.93	0.98	0.96	0.94	0.96	0.92
M5	0	0	0	0		0.97	0.97	0.95	0.93	0.93	0.90	0.86	0.85	0.96	0.96	0.92	0.94	0.94	0.96	0.98	0.95	0.93
M6	0	0	0	0	0		0.95	0.97	0.95	0.91	0.92	0.84	0.83	0.97	0.94	0.89	0.92	0.92	0.94	0.96	0.93	0.91
M7	0	0	0	0	0	0		0.92	0.91	0.95	0.88	0.87	0.88	0.94	0.96	0.93	0.96	0.97	0.98	0.98	0.97	0.95
M8	0	0	0	0	0	0	0		0.96	0.89	0.93	0.84	0.82	0.95	0.91	0.88	0.91	0.89	0.91	0.93	0.91	0.89
M9	0	0	0	0	0	0	0	0		0.87	0.96	0.82	0.79	0.93	0.90	0.85	0.88	0.88	0.89	0.92	0.89	0.88
M10	0	0	0	0	0	0	0	0	0		0.84	0.90	0.89	0.89	0.92	0.95	0.93	0.97	0.96	0.95	0.97	0.91
M11	0	0	0	0	0	0	0	0	0	0		0.82	0.78	0.90	0.87	0.83	0.86	0.86	0.87	0.89	0.87	0.85
M12	0	0	0	0	0	0	0	0	0	0	0		0.92	0.87	0.90	0.91	0.90	0.89	0.88	0.87	0.90	0.90
M13	0	0	0	0	0	0	0	0	1	0	0	0		0.83	0.86	0.88	0.86	0.90	0.89	0.87	0.89	0.85
M14	0	0	0	0	0	0	0	0	0	0	0	0	0		0.96	0.92	0.95	0.91	0.92	0.94	0.92	0.94
M15	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.95	0.97	0.94	0.95	0.96	0.94	0.97
M16A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.97	0.95	0.94	0.92	0.96	0.95
M16B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.95	0.96	0.95	0.95	0.97
I1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.96	0.91	0.96	0.83
I2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.94	0.96	0.85
I3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.93	0.84
I4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.82
I5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

|<-- # of detector pairs having BBR out-of-Spec -->|

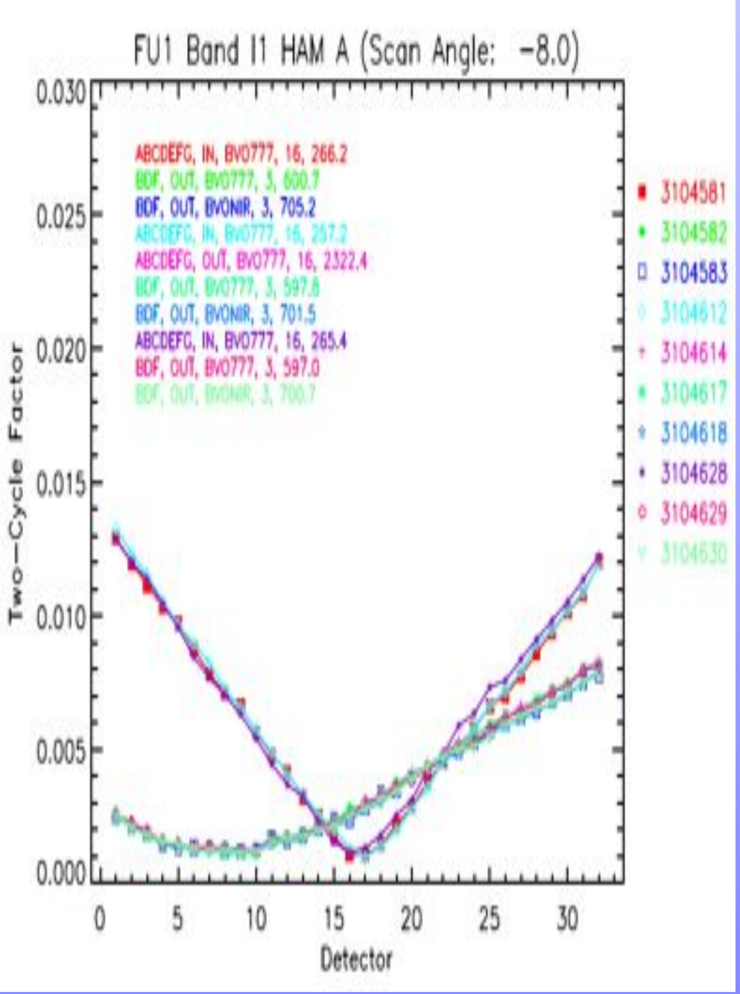
|<---------- # of detector pairs having BBR out-of-Spec ---------->|

|<Worst BBR = Minimum(DDR pairs for HAM A and B sides) >|

- **Lower-left = # of Det out of Spec, upper-right = test results.**
- **Worst BBR meets Spec in Agg1 zone (+/-56.28,+/-44.86 deg) with bow-tie deletion, except 1 det pair M13 vs M9. BBR in Agg2 (+/-44.86, +/-31.72) and Agg3 (-31.72, +31.72 Deg) is better.**
- **The root cause of the out of Spec BBR pair (M13 vs M9) is primarily due to effective focal length (EFL) to scan rate mismatch.**
- **Yellow cells: BBR with <= 5% margin in the ground tests which may be out-of-Spec when in orbit with effects of S/C jitter etc.**

VIIRS F1 Polarization Performance

Polarizarion Requirements		
Band	**Center Wavelength (mm)**	**Maximum Polarization Sensitivity**
M1	0.412	3%
M2	0.445	2.50%
M3	0.488	2.50%
M4	0.555	2.50%
I1	0.64	2.50%
M5	0.672	2.50%
M6	0.746	2.50%
I2	0.865	3%
M7	0.865	3%



All Bands Meet Polarization Requirements

VIIRS Radiometric Requirements: Emissive Bands

Band	λc (μm)	Scene Temperature				
		190K	230K	270K	310K	340K
M12	3.7	N/A	7.00%	0.70%	0.70%	0.70%
M13	4.05	N/A	5.70%	0.70%	0.70%	0.70%
M14	8.55	12.30%	2.40%	0.60%	0.40%	0.50%
M15	10.763	2.10%	0.60%	0.40%	0.40%	0.40%
M16	12.013	1.60%	0.60%	0.40%	0.40%	0.40%

TABLE 17: Absolute radiometric calibration uncertainty of spectral radiance for moderate resolution emissive bands

All Reflective Bands Meet Radiometric Requirements With Margins

VIIRS F1 Performance Status

Based on sensor level TV testing

Reflective Solar Band (RSB) Performance

Performance	Requirement Verification	Expected Risk to EDRs
SNR	All RSB bands meet SNR specifications with margin	Low
Dynamic Range	M1 and I2 slightly not compliant	Low
	M8 not compliant	Low
Gain Transition	Only M1 is not compliant. Margin is about -10% of Lmax.	Low
Linearity	All RSB bands meet Linearity specification with margin	Low
Uniformity	1 NeDL requirement not met for some cases	Medium
Uncertainty	All bands are meeting specification	Low
Stability	All RSB bands meet Stability requirements with margin	Low

Thermal Emissive Band (TEB) Performance

Performance	Requirement Verification	Expected Risk to EDRs
NEdT	All TEB bands meet NeDT specifications with margin	Low
Dynamic Range	All TEB bands compliant for Lmax.	Low
Gain Transition	Only M13 is slightly not compliant.	Low
Linearity	All TEB bands meet Linearity specification with margin	Low
Uniformity	All TEB bands meeting uniformity requirement (1NeDL)	Low
Absolute Calibration	All TEB bands are meeting specification with margins	Low
Stability	All TEB bands meet Stability requirements with margin	Low

Spatial Performance

Performance	Requirement Verification	Expected Risk to
Line Spread Function (LSF)	Scan DFOV is compliant for majority of M-bands and I-bands.	Low
	Track IFOV is compliant for all M-Bands and I-bands, Except M12 Det #1.	Low
	Scan MTF is compliant for majority of M-bands	Low
	Track MTF is compliant for all M-Bands.	Low
	Scan HSR is compliant for majority of I-bands	Low
	Track HSR iscompliant for all I-bands	Low
Band to Band Registration (BBR)	BBR is compliant for all band pairs, except few cases	Low
Pointing Stability	Pointing stability is compliant, except daily stability in track direction	Low

Spectral RSR Performance

Performance	Requirement Verification	Expected Risk to EDRs
Spectral Band Center	Only M4 and M16 are slightly not meeting specification	Low
Spectral Bandwidth	Only M2, M8 and M14 slightly not compliant. M16A Detectors #5-7 also slightly not compliant	Low
Extended Bandwidth	Only I5 is slightly not compliant for the upper 1% limit	Low
Integrated Out-Of-Band	Many bands are not compliant. However, OOB is well characterized	Medium-High
Band to Band Crosstalk	Many bands are not compliant. However, crosstalk characterization will support on-orbit mitigation.	Medium-High

- VIIRS F1 test program is complete and has provided good test data to assess sensor performance.
- Sensor performance exceeds requirements in most cases, and non compliances were addressed in waiver packages and impact assessments
- NASA performance assessments are beginning of life (BOL). Modeling of EOL performances are available in Raytheon Performance Verification Reports (PVRs).
- Government team finalized VIIRS F1 Performance assessments to generate on-orbit LUTs for SDR algorithm

VIIRS F1 Bands and SNR/NEDT

		Band No.	Driving EDR(s)	Spectral Range (um) (Specification)	Horiz Sample Interval (km) (track x Scan) Nadir (Specification)	Horiz Sample Interval (km) (track x Scan) End of Scan (Specification)	Band Gain (Specification)	Ltyp or Ttyp (Spec) (Specification)	Lmax or Tmax (Specification)	SNR or NEdT (K) (Specification)	Measured SNR or NEdT (K)	SNR Margin (%)
Reflective Bands	VisNIR	M1	Ocean Color Aerosol	0.402 - 0.422	0.742 x 0.259	1.60 x 1.58	High Low	44.9 155	135 615	352 316	723 1327	105% 320%
		M2	Ocean Color Aerosol	0.436 - 0.454	0.742 x 0.259	1.60 x 1.58	High Low	40 146	127 687	380 409	576 1076	51.5% 163%
		M3	Ocean Color Aerosol	0.478 - 0.498	0.742 x 0.259	1.60 x 1.58	High Low	32 123	107 702	416 414	658 1055	58.2% 155%
		M4	Ocean Color Aerosol	0.545 - 0.565	0.742 x 0.259	1.60 x 1.58	High Low	21 90	78 667	362 315	558 882	54.1% 180%
		I1	Imagery EDR	0.600 - 0.680	0.371 x 0.387	0.80 x 0.789	Single	22	718	119	265	122.7%
		M5	Ocean Color Aerosol	0.662 - 0.682	0.742 x 0.259	1.60 x 1.58	High Low	10 68	59 651	242 360	360 847	49% 135%
		M6	Atmosph. Correct.	0.739 - 0.754	0.742 x 0.776	1.60 x 1.58	Single	9.6	41	199	394	98.0%
		I2	NDVI	0.846 - 0.885	0.371 x 0.387	0.80 x 0.789	Single	25	349	150	299	99.3%
		M7	Ocean Color Aerosol	0.846 - 0.885	0.742 x 0.259	1.60 x 1.58	High Low	6.4 33.4	29 349	215 340	545 899	154% 164%
	S/MWIR	M8	Cloud Particle Size	1.230 - 1.250	0.742 x 0.776	1.60 x 1.58	Single	5.4	165	74	349	371.6%
		M9	Cirrius/Cloud Cover	1.371 - 1.386	0.742 x 0.776	1.60 x 1.58	Single	6	77.1	83	247	197.6%
		I3	Binary Snow Map	1.580 - 1.640	0.371 x 0.387	0.80 x 0.789	Single	7.3	72.5	6	165	2650.0%
		M10	Snow Fraction	1.580 - 1.640	0.742 x 0.776	1.60 x 1.58	Single	7.3	71.2	342	695	103.2%
		M11	Clouds	2.225 - 2.275	0.742 x 0.776	1.60 x 1.58	Single	0.12	31.8	10	18	80.0%
Emissive Bands		I4	Imagery Clouds	3.550 - 3.930	0.371 x 0.387	0.80 x 0.789	Single	270	353	2.5	0.4	84.0%
		M12	SST	3.660 - 3.840	0.742 x 0.776	1.60 x 1.58	Single	270	353	0.396	0.12	69.7%
		M13	SST Fires	3.973 - 4.128	0.742 x 0.259	1.60 x 1.58	High Low	300 380	343 634	0.107 0.423	0.044 --	59% --
	LWIR	M14	Cloud Top Properties	8.400 - 8.700	0.742 x 0.776	1.60 x 1.58	Single	270	336	0.091	0.054	40.7%
		M15	SST	10.263 - 11.263	0.742 x 0.776	1.60 x 1.58	Single	300	343	0.07	0.028	60.0%
		I5	Cloud Imagery	10.500 - 12.400	0.371 x 0.387	0.80 x 0.789	Single	210	340	1.5	0.41	72.7%
		M16	SST	11.538 - 12.488	0.742 x 0.776	1.60 x 1.58	Single	300	340	0.072	0.036	50.0%

All Bands Meet SNR Requirements With Margin

TABLE 5. VIIRS Spectral band optical requirements

Band	Center Wavelength (nm)	Tolerance on Center Wavelength (± nm)	Bandwidth (nm)	Tolerance on Bandwidth (± nm)	OOB Integration Limits (lower, upper) (nm)	Maximum Integrated OOB Response (%)	Character-ization Uncertainty (nm)
M1	412	2	20	2	≥376, ≤444	1.0	1
M2	445	3	18	2	≥417, ≤473	1.0	1
M3	488	4	20	3	≥455, ≤521	0.7	1
M4	555	4	20	3	≥523, ≤589	0.7	1
M5	672	5	20	3	≥638,≤706	0.7	1
M6	746	2	15	2	≥721, ≤771	0.8	1
M7	865	8	39	5	≥801, ≤929	0.7	1.3
M8	1240	5	20	4	≥1205, ≤1275	0.8	1
M9	1378	4	15	3	≥1351, ≤1405	1.0	1
M10	1610	14	60	9	≥1509, ≤1709	0.7	2.3
M11	2250	13	50	6	≥2167, ≤2333	1.0	1.9
M12	3700	32	180	20	≥3410, ≤3990	1.1	3.7
M13	4050	34	155	20	≥3790, ≤4310	1.3	3
M14	8550	70	300	40	≥8050, ≤9050	0.9	11
M15	10763	113	1000	100	≥9700, ≤11740	0.4	10.8
M16	12013	88	950	50	≥11060, ≤13050	0.4	6
DNB	700	14	400	20	≥470, ≤960	0.1	1
I1	640	6	80	6	≥565, ≤715	0.5	1
I2	865	8	39	5	≥802, ≤928	0.7	1.3
I3	1610	14	60	9	≥1509, ≤1709	0.7	2.3
I4	3740	40	380	30	≥3340, ≤4140	0.5	3.7
I5	11450	125	1900	100	≥9900, ≤12900	0.4	20

[1] The values given under "OOB Integration Limits" are the specified limits on the 1% relative response points.
[2] The OOB integration limits will be the 1% response points determined during sensor characterization.

TABLE 12. Dynamic range requirements for VIIRS Sensor reflective bands

			Single Gain		Dual Gain			
					High Gain		Low Gain	
Band	Center Wavelength (nm)	Gain Type	Lmin	Lmax	Lmin	Lmax	Lmin	Lmax
M1	412	Dual	-	-	30	135	135	615
M2	445	Dual	-	-	26	127	127	687
M3	488	Dual	-	-	22	107	107	702
M4	555	Dual	-	-	12	78	78	667
M5	672	Dual	-	-	8.6	59	59	651
M6	746	Single	5.3	41.0	-	-	-	-
M7	865	Dual	-	-	3.4	29	29	349
M8	1240	Single	3.5	164.9	-	-	-	-
M9	1378	Single	0.6	77.1	-	-	-	-
M10	1610	Single	1.2	71.2	-	-	-	-
M11	2250	Single	0.12	31.8	-	-	-	-
I1	640	Single	5	718	-	-	-	-
I2	865	Single	10.3	349	-	-	-	-
I3	1610	Single	1.2	72.5	-	-	-	-

Spectral radiance (Lmin and Lmax) has units of watt m-2 sr-1 μm-1.

TABLE 13. Dynamic range requirements VIIRS Sensor emissive bands

			Single Gain		Dual Gain			
					High Gain		Low Gain	
Band	Center Wavelength (nm)	Gain Type	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax
M12	3700	Single	230	353	-	-	-	-
M13	4050	Dual	-	-	230	343	343	634
M14	8550	Single	190	336	-	-	-	-
M15	10763	Single	190	343	-	-	-	-
M16	12013	Single	190	340	-	-	-	-
I4	3740	Single	210	353	-	-	-	-
I5	11450	Single	190	340	-	-	-	-

TABLE 14: Sensitivity requirements for VIIRS Sensor reflective bands

			Single Gain		Dual Gain			
					High Gain		Low Gain	
Band	Center Wavelength (nm)	Gain Type	Ltyp	SNR	Ltyp	SNR	Ltyp	SNR
M1	412	Dual	-	-	44.9	352	155	316
M2	445	Dual	-	-	40	380	146	409
M3	488	Dual	-	-	32	416	123	414
M4	555	Dual	-	-	21	362	90	315
M5	672	Dual	-	-	10	242	68	360
M6	746	Single	9.6	199	-	-	-	-
M7	865	Dual	-	-	6.4	215	33.4	340
M8	1240	Single	5.4	74	-	-	-	-
M9	1378	Single	6	83	-	-	-	-
M10	1610	Single	7.3	342	-	-	-	-
M11	2250	Single	0.12	10	-	-	-	-
I1	640	Single	22	119	-	-	-	-
I2	865	Single	25	150	-	-	-	-
I3	1610	Single	7.3	6	-	-	-	-

Notes:
The units of spectral radiance for Ltyp are watt m-2 sr-1 µm-1.
The SNR column shows the minimum required (worst-case) SNR that applies at the end-of-scan.

TABLE 15: Sensitivity requirements for VIIRS Sensor emissive bands

			Single Gain		Dual Gain			
					High Gain		Low Gain	
Band	Center Wavelength (nm)	Gain Type	Ttyp	NEdT	Ttyp	NEdT	Ttyp	NEdT
M12	3700	Single	270	0.396	-	-	-	-
M13	4050	Dual	-	-	300	0.107	380	0.423
M14	8550	Single	270	0.091	-	-	-	-
M15	10763	Single	300	0.070	-	-	-	-
M16	12013	Single	300	0.072	-	-	-	-
I4	3740	Single	270	2.500	-	-	-	-
I5	11450	Single	210	1.500	-	-	-	-

Table # 17/18: Emissive Bands Radiometric Calibration Accuracy Requirements

		Scene Temperature				
Band	λ_c (μm)	190K	230K	270K	310K	340K
M12	3.7	N.A.	7.0%	0.7%	0.7%	0.7%
M13	4.05	N.A.	5.7%	0.7%	0.7%	0.7%
M14	8.55	12.3%	2.4%	0.6%	0.4%	0.5%
M15	10.763	2.1%	0.6%	0.4%	0.4%	0.4%
M16	12.013	1.6%	0.6%	0.4%	0.4%	0.4%

Band	Center Wavelength (nm)	Calibration Uncertainty
I4	3740	5.0%
I5	11450	2.5%

Equivalent or Better Performance Was Achieved on MODIS

VIIRS F1 Spectral Performance

Meets all Requirements for:

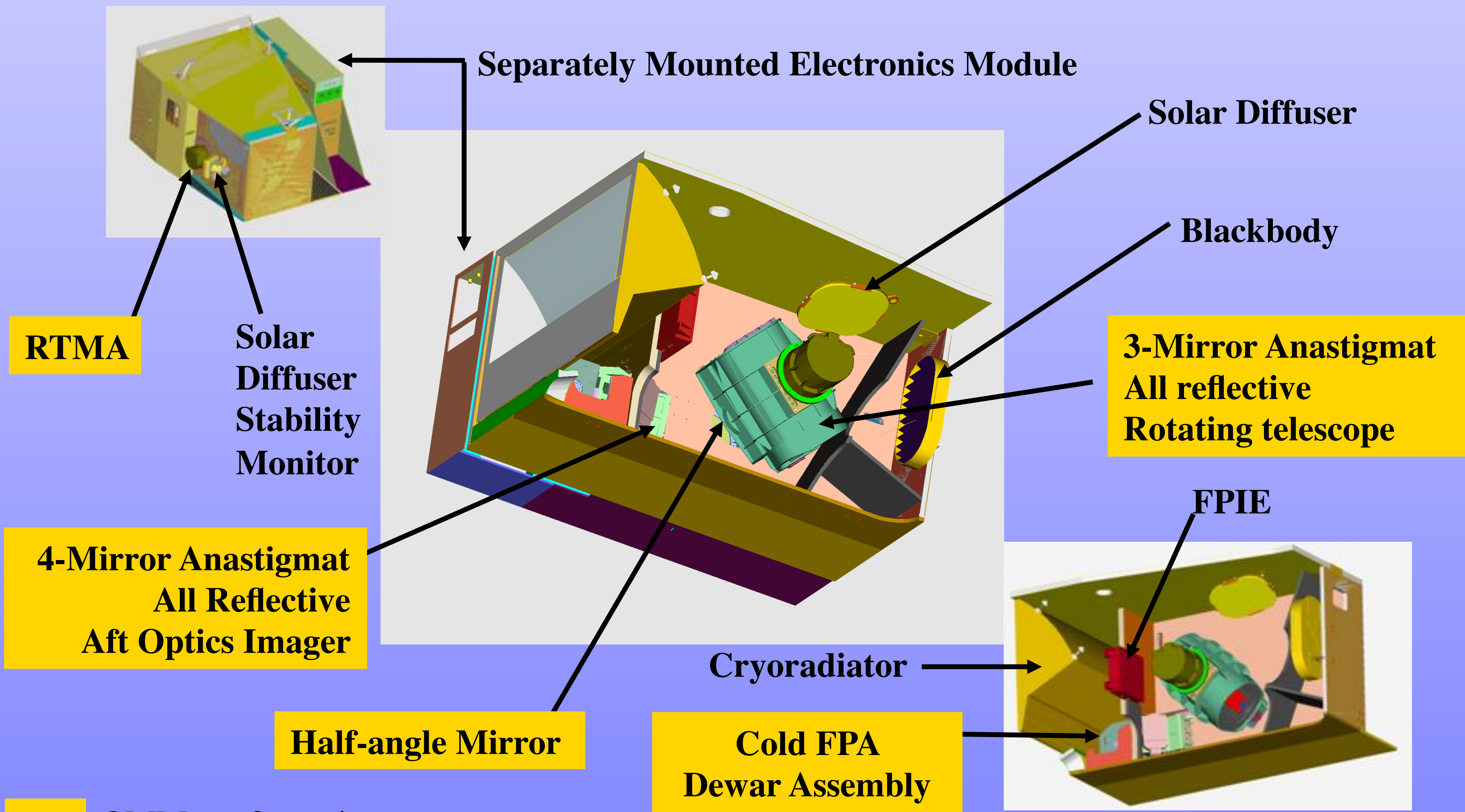
Spectral Band Center, Spectral Bandwidth, Extended Bandwidth

Significant Non-Compliance for: Integrated Out-of-Band Response

Band	Center Wavelength (nm)	Bandwidth (nm)	Requirement Maximum Integrated OOB Response (%)	Measured Maximum Integrated OOB Response (%)
M1	412	20	1.0	3.7
M3	488	20	0.7	1.1
M4	555	20	0.7	4.3
M5	672	20	0.7	3.2
M6	746	15	0.8	1.8

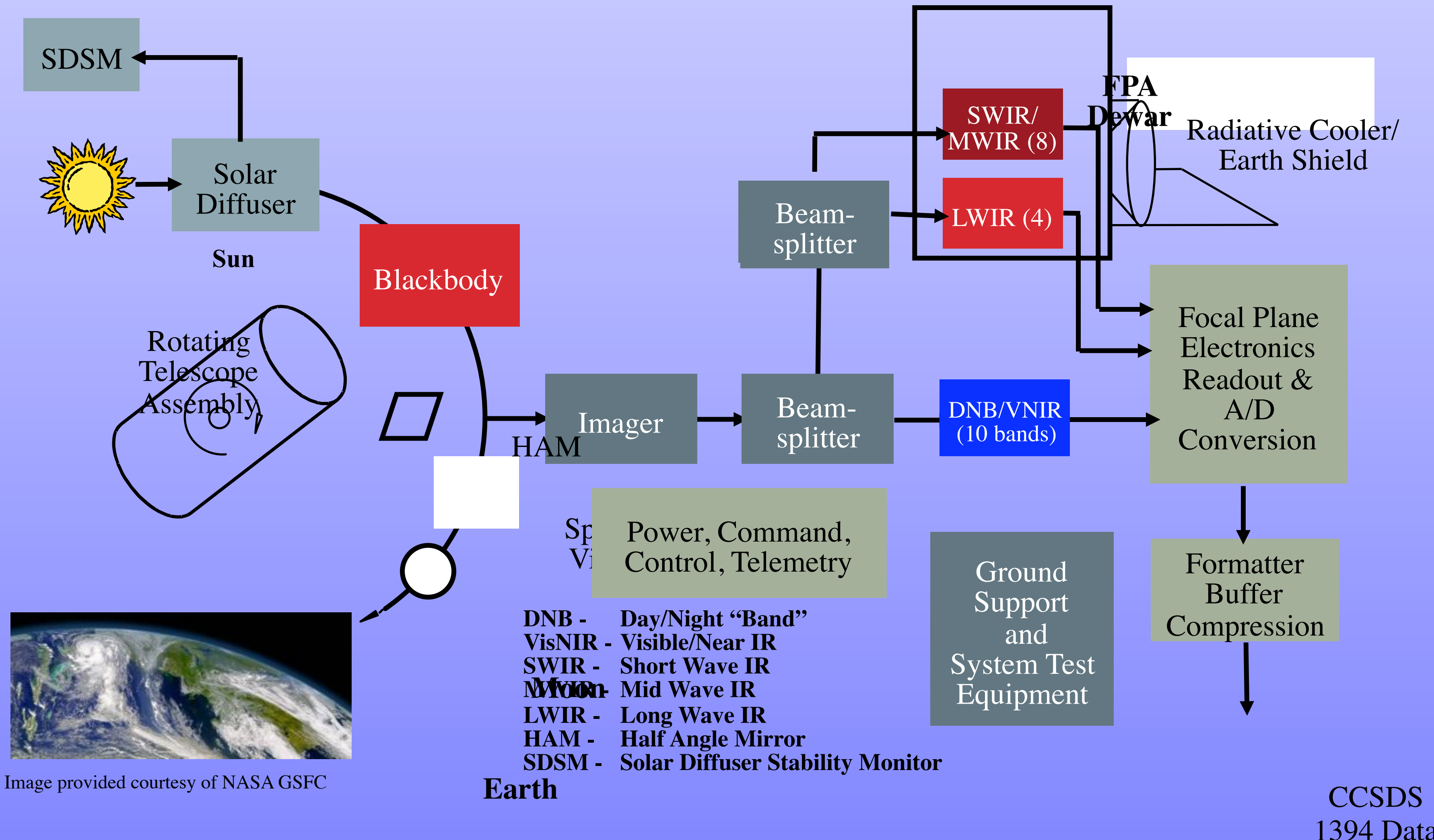
Notes: Smaller non-compliances for emissive bands
Well characterized
Difficult to separate from Cross-talk effects

VIIRS Incorporates Modular Sensor Approach



OMM configuration

VIIRS F1 Sensor Block Diagram



DNB - **Day/Night "Band"**
VisNIR - **Visible/Near IR**
SWIR - **Short Wave IR**
MWIR - **Mid Wave IR**
LWIR - **Long Wave IR**
HAM - **Half Angle Mirror**
SDSM - **Solar Diffuser Stability Monitor**

Image provided courtesy of NASA GSFC

VIIRS Bands and Products

VIIRS 22 Bands:
16 M-Band, 5 I-Band and 1 DNB

VIIRS Band	Spectral Range (um)	Nadir HSR (m)	MODIS Band(s)	Range	HSR
DNB	0.500 - 0.900				
● M1	0.402 - 0.422	750	8	0.405 - 0.420	1000
● M2	0.436 - 0.454	750	9	0.438 - 0.448	1000
● M3	0.478 - 0.498	750	3 10	0.459 - 0.479 0.483 - 0.493	500 1000
● M4	0.545 - 0.565	750	4 or 12	0.545 - 0.565 0.546 - 0.556	500 1000
I1	0.600 - 0.680	375	1	0.620 - 0.670	250
● M5	0.662 - 0.682	750	13 or 14	0.662 - 0.672 0.673 - 0.683	1000 1000
M6	0.739 - 0.754	750	15	0.743 - 0.753	1000
I2	0.846 - 0.885	375	2	0.841 - 0.876	250
● M7	0.846 - 0.885	750	16 or 2	0.862 - 0.877 0.841 - 0.876	1000 250
M8	1.230 - 1.250	750	5	SAME	500
M9	1.371 - 1.386	750	26	1.360 - 1.390	1000
I3	1.580 - 1.640	375	6	1.628 - 1.652	500
M10	1.580 - 1.640	750	6	1.628 - 1.652	500
M11	2.225 - 2.275	750	7	2.105 - 2.155	500
I4	3.550 - 3.930	375	20	3.660 - 3.840	1000
M12	3.660 - 3.840	750	20	SAME	1000
● M13	3.973 - 4.128	750	21 or 22	3.929 - 3.989 3.929 - 3.989	1000 1000
M14	8.400 - 8.700	750	29	SAME	1000
M15	10.263 - 11.263	750	31	10.780 - 11.280	1000
I5	10.500 - 12.400	375	31 or 32	10.780 - 11.280 11.770 - 12.270	1000 1000
M16	11.538 - 12.488	750	32	11.770 - 12.270	1000

● Dual gain band

Similar MODIS bands are shown for comparison

VIIRS 24 EDRs
Land, Ocean, Cloud, Snow

Name of Product	Group	Type
Imagery *	Imagery	EDR
Precipitable Water	Atmosphere	EDR
Suspended Matter	Atmosphere	EDR
Aerosol Optical Thickness	Aerosol	EDR
Aerosol Particle Size	Aerosol	EDR
Cloud Base Height	Cloud	EDR
Cloud Cover/Layers	Cloud	EDR
Cloud Effective Particle Size	Cloud	EDR
Cloud Optical Thickness/Transmittance	Cloud	EDR
Cloud Top Height	Cloud	EDR
Cloud Top Pressure	Cloud	EDR
Cloud Top Temperature	Cloud	EDR
Active Fires	Land	Application
Albedo (Surface)	Land	EDR
Land Surface Temperature	Land	EDR
Soil Moisture	Land	EDR
Surface Type	Land	EDR
Vegetation Index	Land	EDR
Sea Surface Temperature *	Ocean	EDR
Ocean Color and Chlorophyll	Ocean	EDR
Net Heat Flux	Ocean	EDR
Sea Ice Characterization	Snow and Ice	EDR
Ice Surface Temperature	Snow and Ice	EDR
Snow Cover and Depth	Snow and Ice	EDR

* Product is a Key Performance Parameter (KPP)

VIIRS Spectral, Spatial, & Radiometric Attributes

		Band No.	Wave-length (μm)	Horiz Sample Interval (km Downtrack x Crosstrack)		Driving EDRs	Radi-ance Range	Ltyp or Ttyp	Signal to Noise Ratio (dimensionless) or NEΔT (Kelvins)		
				Nadir	End of Scan				Required	Predicted	Margin
VIS/NIR FPA	Silicon PIN Diodes	M1	0.412	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	44.9	352	441	25%
						Aerosols	High	155	316	807	155%
		M2	0.445	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	40	380	524	38%
						Aerosols	High	146	409	926	126%
		M3	0.488	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	32	416	542	30%
						Aerosols	High	123	414	730	76%
		M4	0.555	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	21	362	455	26%
						Aerosols	High	90	315	638	102%
		I1	0.640	0.371 x 0.387	0.80 x 0.789	Imagery	Single	22	119	146	23%
		M5	0.672	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	10	242	298	23%
						Aerosols	High	68	360	522	45%
		M6	0.746	0.742 x 0.776	1.60 x 1.58	Atmospheric Corr'n	Single	9.6	199	239	20%
		I2	0.865	0.371 x 0.387	0.80 x 0.789	NDVI	Single	25	150	225	50%
		M7	0.865	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	6.4	215	388	81%
						Aerosols	High	33.4	340	494	45%
CCD		DNB	0.7	0.742 x 0.742	0.742 x 0.742	Imagery	Var.	6.70E-05	6	5.7	-5%
S/MWIR	PV HgCdTe (HCT)	M8	1.24	0.742 x 0.776	1.60 x 1.58	Cloud Particle Size	Single	5.4	74	98	32%
		M9	1.378	0.742 x 0.776	1.60 x 1.58	Cirrus/Cloud Cover	Single	6	83	155	88%
		I3	1.61	0.371 x 0.387	0.80 x 0.789	Binary Snow Map	Single	7.3	6.0	97	1523%
		M10	1.61	0.742 x 0.776	1.60 x 1.58	Snow Fraction	Single	7.3	342	439	28%
		M11	2.25	0.742 x 0.776	1.60 x 1.58	Clouds	Single	0.12	10	17	66%
		I4	3.74	0.371 x 0.387	0.80 x 0.789	Imagery Clouds	Single	270 K	2.500	0.486	415%
		M12	3.70	0.742 x 0.776	1.60 x 1.58	SST	Single	270 K	0.396	0.218	82%
		M13	4.05	0.742 x 0.259	1.60 x 1.58	SST	Low	300 K	0.107	0.063	69%
						Fires	High	380 K	0.423	0.334	27%
LWIR	PV HCT	M14	8.55	0.742 x 0.776	1.60 x 1.58	Cloud Top Properties	Single	270 K	0.091	0.075	22%
		M15	10.763	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K	0.070	0.038	85%
		I5	11.450	0.371 x 0.387	0.80 x 0.789	Cloud Imagery	Single	210 K	1.500	0.789	90%
		M16	12.013	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K	0.072	0.051	42%

VIIRS F1 Sensor Gov't Activities

- VIIRS F1 testing program is complete and has provided test data to support 141 performance requirements
- NASA team has completed extensive analysis of VIIRS test data
  - Support of sensor test data analysis, and requirement verification
    - Release more than 130 reports and memos just Instrument TV phase
  - Support to Waiver evaluation, including SDR/EDR impact assessment

NICST Data Analysis Satellite TV Summaries:

- NICST team released five (5) Summaries on Friday April 22nd in support of the SC TVAC CTB meeting held on April 23rd. These VIIRS summaries represent NICST's assessments of the overall VIIRS SC TVAC performance testing,
- NICST is planning to develop detailed reports for VIIRS performance assessment based on SC TVAC testing.

- NICST team summaries did not identify any specific concern or issue, and have shown that all VIIRS data collected and analyzed are of good quality and sufficient to verify that sensor performance is as expected.

Team Coordination

NASA

- NPP Instrument Characterization Support Team (NICST)
- NPP Instrument Calibration and Support Element (NICSE)
- MODIS Characterization Support Team (MCST)
- VIIRS Ocean Science Team (VOST)
- University of Wisconsin (UW)
- Project Science Office (PSO)

NOAA

- Aerospace Cooperation
- MIT/LL

Contractors

- Northrop Grumman
- Raytheon SBRS and El-Segundo
- Ball Aerospace