NPP/VIIRS: Status and Expected Science Capability

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NPP Project Scientist

Contributions from:

Government VIIRS Data Analysis Working Group

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

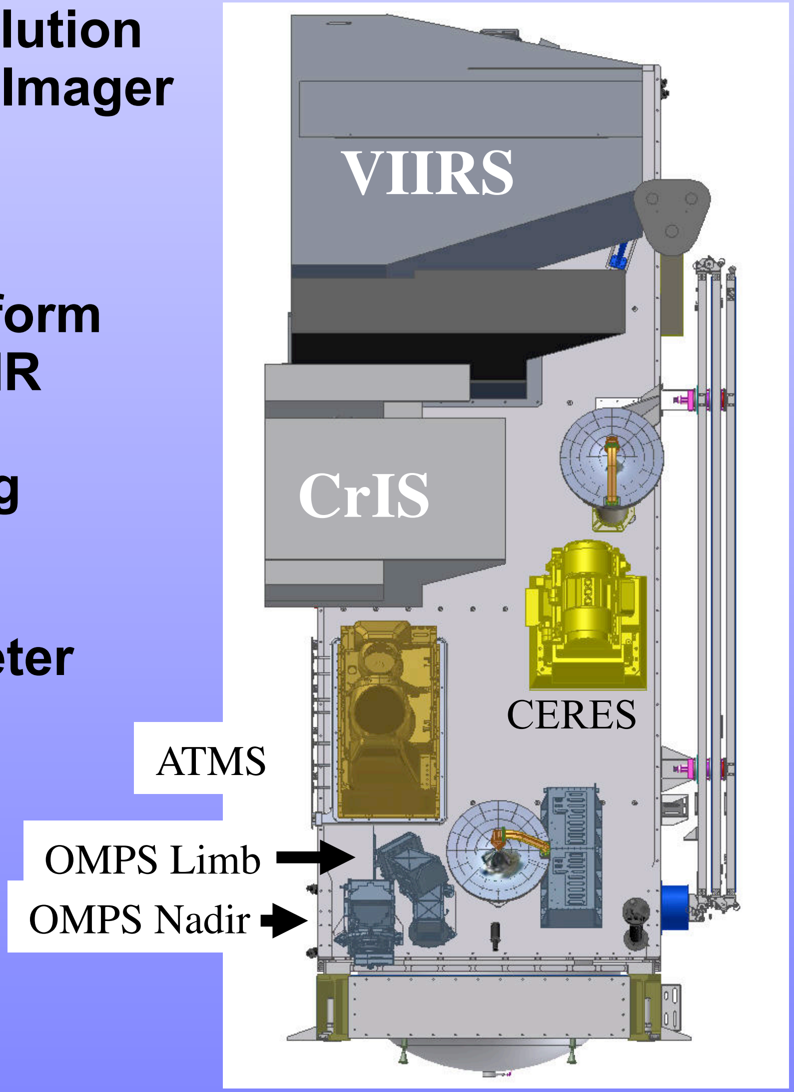
NPP Status: What instruments are on NPP?

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

Initial concept	**2/07**
Confirmed	**2/08**
On spacecraft	**11/08**

CERES Flight Model 5

CERES scanning radiometer measuring three spectral bands at TOA
- Total (0.3 to >50 μm)
- Shortwave (0.3 to 5.0 μm)
- Longwave Bandpass (8 to 12 μm)

Operations, Data Processing, Products, and Science are a continuation of experience developed on
- TRMM (1), EOS Terra (2), EOS Aqua (2)

Current Status: On NPP

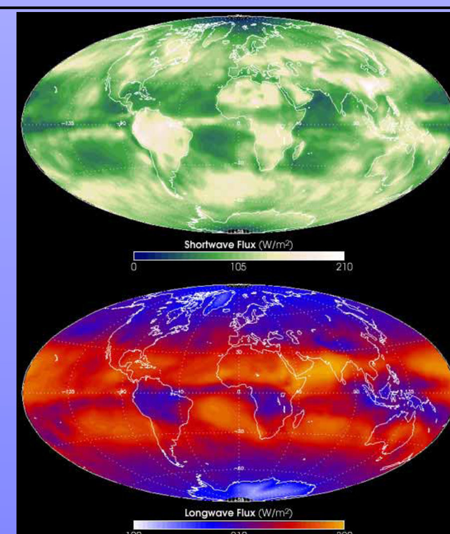
Margins

CERES	Spec	CBE
Mass - kg	50	50
Power (Avg.) - W	50	50
Power (Max) - W	75	75
Data Rate (Avg.) - Kbps	10	10
Data Rate (Max) - Kbps	10	10

Primary CERES Climate Data Records

Reflected Solar Energy

Emitted Thermal Energy



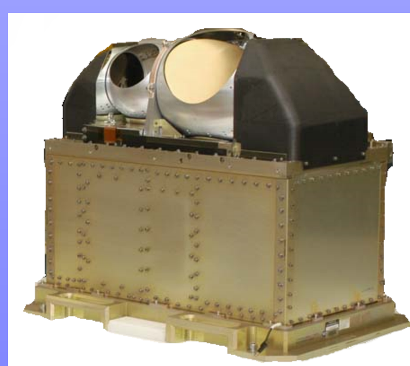
Temperature & Water Vapor Profiles

Advanced Technology Microwave Sounder

- Scanning passive microwave radiometer
- Combines 3 instruments
  - AMSU A1 / A2, MHS
- (22 channels (23GHz - 183GHz)

Status

- Flight Model on Spacecraft

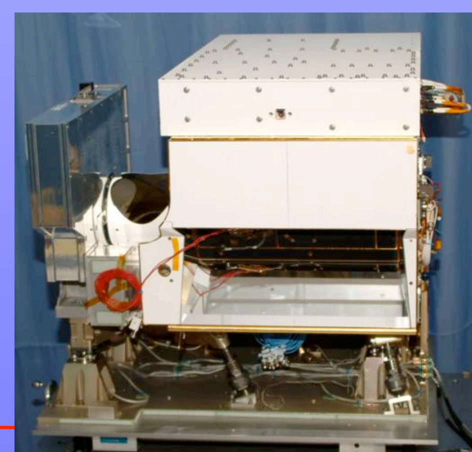


Cross-Track Infrared Sounder

- Michelson Interferometer
  3 bands (3.5 µm - 16 µm)

Status

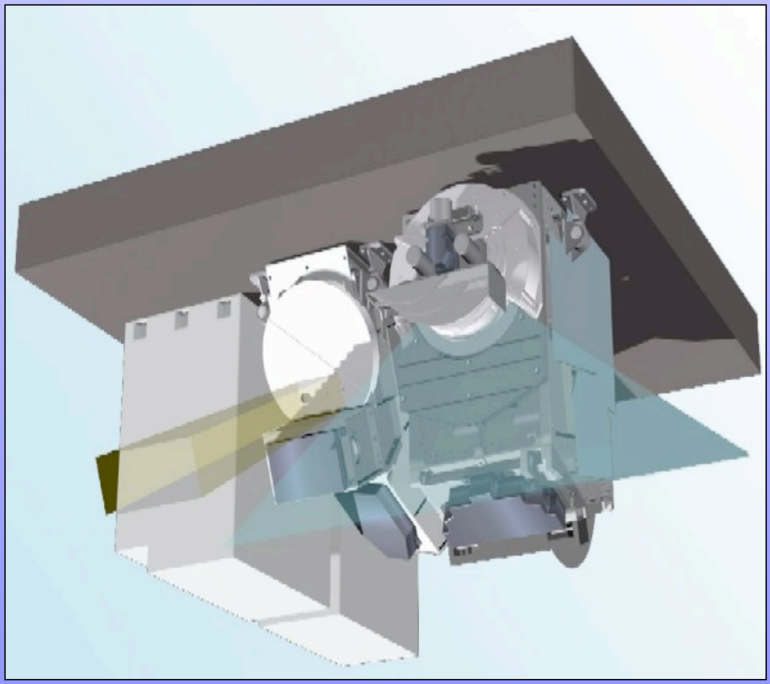
- Flight Unit #1 has finished calibration.
- Electronics Boards Re-built
- Re-Qualifying T/V: Complete
- Ship to NPP: June 2010



Ozone Mapping Profiler Suite

Description

- **Purpose:** Monitors the total column and vertical profile of ozone
- **Predecessor Instruments:** TOMS, SBUV, GOME, OSIRIS, SCIAMACHY
- **Approach:** Nadir and limb push broom CCD spectrometers
- **Swath width:** 2600 km



Status

- Limb re-manifested
- Nadir and Limb has completed TV testing and calibration
- Integrated Instrument on spacecraft

Products: Total ozone maps and SBUV2-like ozone profiles

Higher resolution ozone profiles from Limb instrument

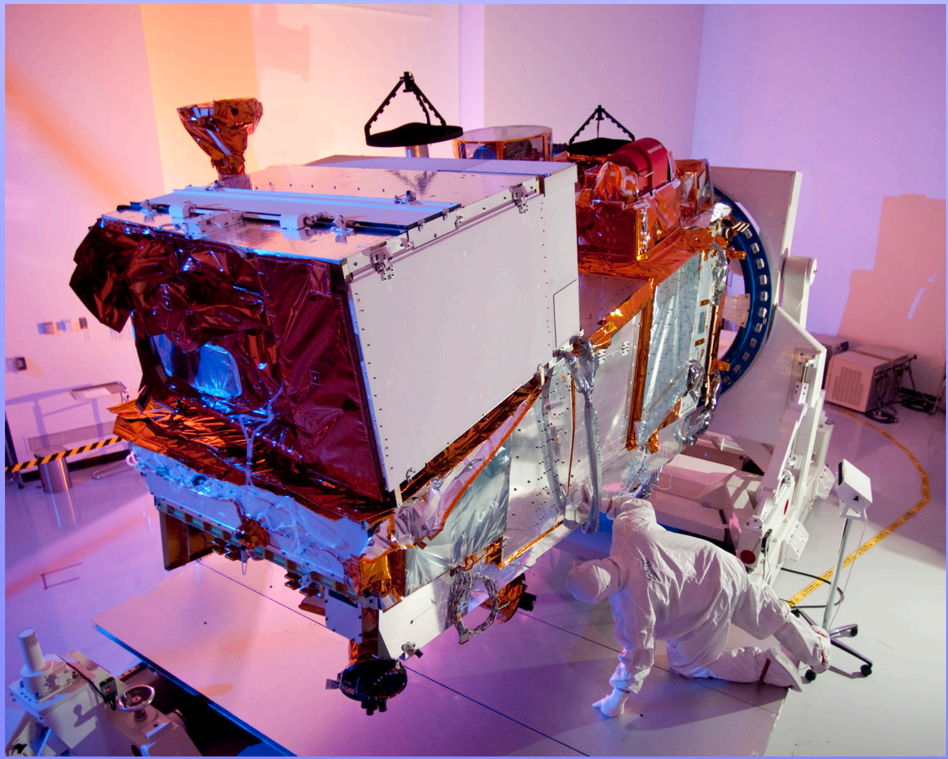
Visible Infrared Imaging Radiometer Suite

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

- Flight Unit #1 Completed Ambient , Vibration, EMI/EMC and Thermal Vacuum characterization, calibration and on spacecraft
- VIIRS on NPP
- VIIRS Testing on Spacecraft: Gain, Relative Spectral Response, End-to-End (NIST) complete



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

Significant Non-Compliance for: Band-to-Band Crosstalk

Optical Crosstalk
The VIIRS Integrated Filter Assembly (IFA), as built, scatters light across the focal plane detector.
This optical scattering is caused by defects in the multi-layer deposition manufacturing process. It is expected that this will be fixed for FM2.

This effect is referred to as optical crosstalk; light from one band in one pixel is measured in another pixel. Test data was taken to quantify the amount of optical crosstalk.

The data product that is most affected is Ocean Color.

NGAS has proposed a correction method. Their methodology is still undergoing government peer-review.

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

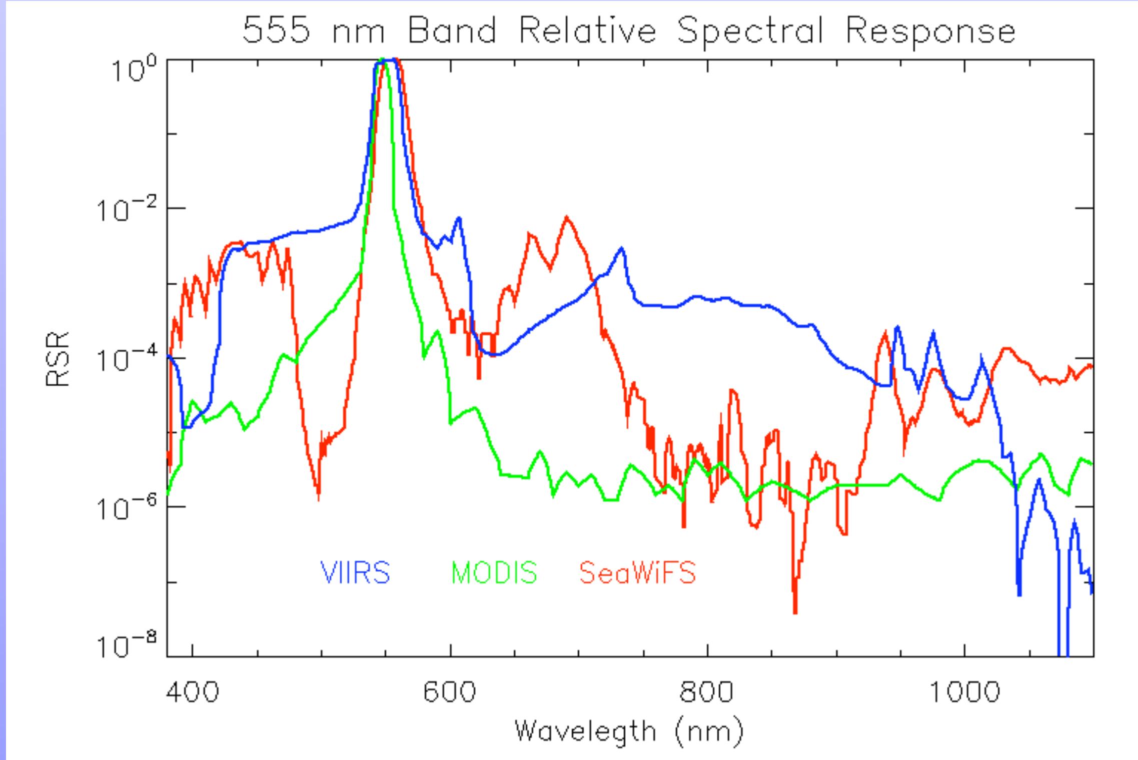
Notes: Smaller non-compliances for emissive bands

Well characterized

More accurate measurements from spacecraft testing (Bruce Guenther presentation tomorrow)

Gov't EDR analysis ongoing

VIIRS EDR Performance: Ocean Color Performance Out-of-Band



"The VIIRS on-orbit performance, due to the OOB calibration biases alone, should be no worse than SeaWiFS. If the VIIRS OOB calibration biases are not adversely complicated by the crosstalk, the heritage OOB mitigation approaches that were developed for SeaWiFS and Aqua MODIS should work for VIIRS. These approaches use vicarious calibration as the primary correction for the OOB bias in the calibrated TOA radiances, then use direct OOB corrections of the water-leaving radiances to remove residual OOB biases."

VIIRS EDR Performance: IPO Requirements

- For most of the EDRs which are not dependent on precise multi-wavelength radiometric calibration (all the EDRs except Ocean Color), the VIIRS instrument performance is expected to be pretty good.

- The VIIRS EDRs will meet their operational performance requirements, with the exception of Ocean Color.

VIIRS EDR Performance:
NASA Science Requirements

Given satisfactory VIIRS performance;

- **EOS data continuity requires algorithm continuity**
- **Similar physics is needed to reduce systematic errors**
- **Not all current VIIR EDRS use current MODIS algorithms**

Need to adapt where instruments differ,

- **MODIS and VIIRS do not have all the same bands**
- **Band Aggregation is a challenge**

VIIRS EDR Performance: NASA Science Requirements

Land:

IDPS products should meet operational needs

Minimal effects from cross-talk

Land Surface Reflectance, Surface Albedo, and Vegetation Index have significant algorithmic differences with current EOS products

Active Fires products are a special case due to instrumental differences. Research product being developed for MODIS continuity

VIIRS EDR Performance: NASA Science Requirements

Atmospheres; Aerosols:

- Current IDPS uses MODIS Collection 5
- Current version does not have Deep Blue AOT retrieval over bright land surfaces
- High priority candidate for IDPS update

Largest effect seen from IOOB features

- Can compensated for using measured RSRs in LUT

Cross-talk effects on ocean AOT are minimal

Cross-talk effects on land AOT are small.

- still need to understand polarization effects

VIIRS EDR Performance: NASA Science Requirements

Atmospheres: Cloud Properties see White Paper, Bryan Baum editor

Significant Instrumental differences;

MODIS has CO_2 and H_2O bands

Cloud Mask; Good collaboration

Other Cloud Properties: cloud top height/temperature/pressure, optical thickness, and effective particle size

Major algorithmic differences; no CO_2 slicing bands for cloud height

Minor differences in assumptions for phase function, spectral albedo, ice cloud scattering, max cloud optical thickness

Significant Work needed for EOS Continuity

Minimal Cross talk and IOOB effects

Joint Polar Satellite System

As Briefed by NOAA/NASA
Feb 4, 2010

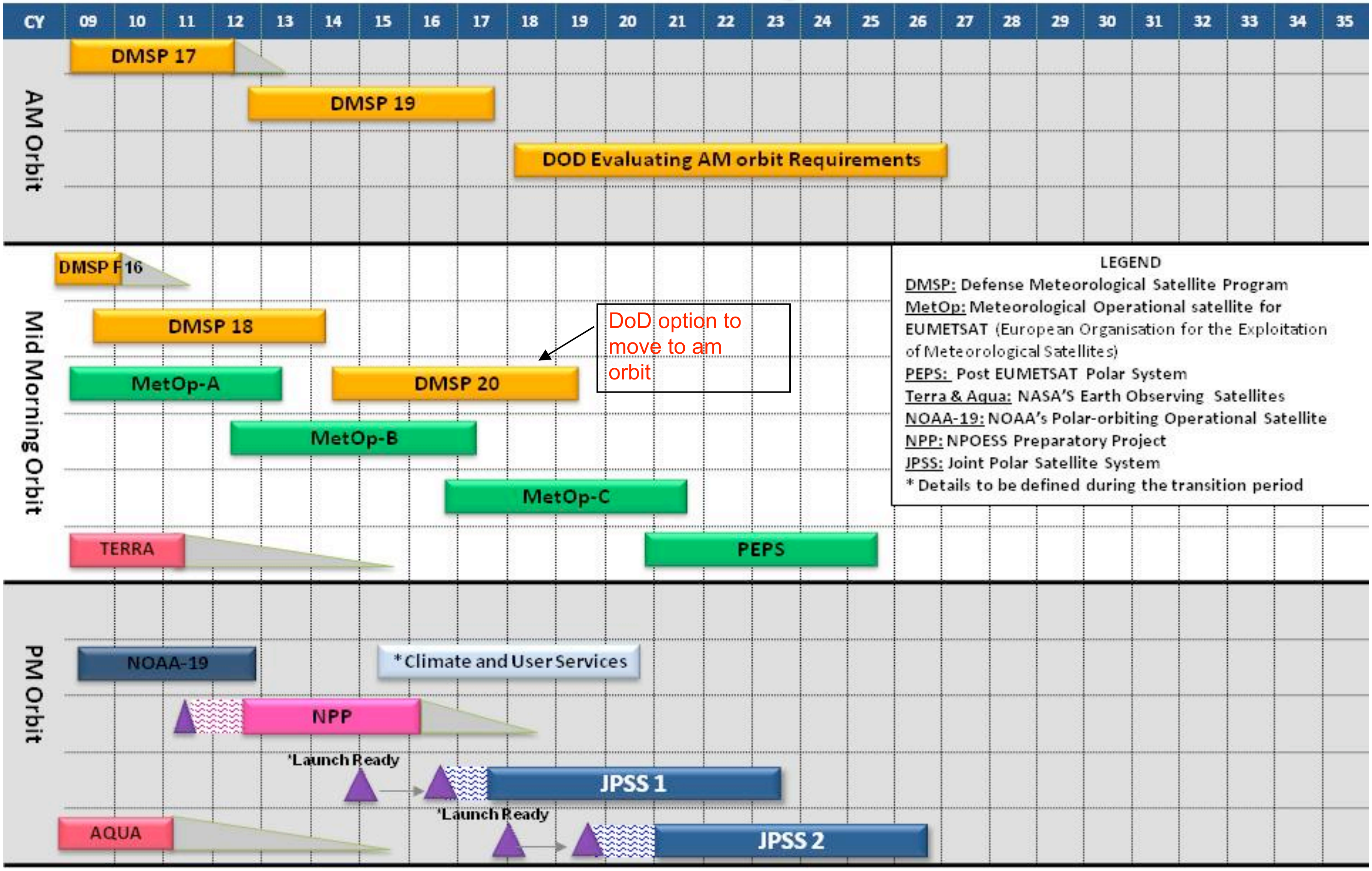
NPOESS Background

- NPOESS is a national priority -- essential to meeting both civil and military weather-forecasting, storm-tracking, and climate-monitoring requirements
- An Administration task force and independent reviews have concluded that the current program cannot be successfully executed with the current management structure, and with the current budget structure.
- These challenges originate in large part because of a combination of management deficiencies that result from conflicting perspectives and priorities among the three agencies who manage the program
- Absent a major restructuring, the Agencies would have continued to face major risks in executing the current program, threatening our ability to ensure weather and climate observations

Administration Decision on Restructuring

- Acquisition responsibilities will be shared
  - NOAA/NASA responsible for the PM orbit – to be called Joint Polar Satellite System (JPSS)
  - DoD (AF/SMC) responsible for the early AM orbit
  - Agencies will share a common ground system to be managed by NOAA/NASA
  - Agencies will share data from each orbit to meet the national need for weather and climate information
- Mid and early-AM orbits covered by EUMETSAT and remaining DOD/DMSP platforms
- Acquire 2 lower risk JPSS satellites
- Observations planned in the PM orbit for NPOESS are maintained
  - VIIRS, CrIS, ATMS, OMPS, and CERES/ERBS remain
  - AMSR sensor data from Japanese GCOM satellite to replace MIS for microwave imaging/sounding
- Continue plan for operational use of NPP data (PM orbit) with a
  - Fall 2011 launch readiness date

Continuity of Polar Operational Satellite Programs



Transition Approach

- NOAA/DoD leadership agree to cooperate to ensure a smooth and transparent transition
- Government Transition Team will immediately develop and execute Transition Plan
- IPO team maintained and continue current efforts in parallel with Transition Team
  - Careful and controlled transition of IPO team from NPOESS to JPSS and other programs
- NOAA/NASA management of JPSS program (PM Orbit) and shared Ground System
  - Maintain work on instruments, ground system, and algorithms that support PM orbit while transitioning those contracts to NASA/GSFC
  - Acquire 2 lower risk JPSS satellites
  - Climate sensor acquisitions (CERES/ERBS, TSIS, OMPS Limb) continue via the NOAA climate program
  - International agreements for SARSAT and ADCS user services payloads remain in place
- Work with DoD/Northrop Grumman Aerospace Systems Procurement organizations to transfer work on Instruments/Ground System to NASA-led acquisition vehicles
- DoD maintains acquisition authority of NGAS contract
  - DoD and NOAA to share any termination costs
- NOAA JPSS Program will be subject to independent review of mission concepts, organizational structure, acquisition strategies, and budget prior to program baseline

NOAA JPSS Budget

- Supports JPSS mission through FY 2026, including shared ground system, and NOAA portion of shared NPOESS termination costs
- Climate instruments TSIS, CERES/ERBS, OMPS Limb are developed under the existing NOAA Climate Program (outside JPSS budget)
- SARSAT, ADCS, and AMSR (data) will be provided by international partners
- Reflects high confidence level cost estimate
- Increased funding in near-years to mitigate risk and support transition

OUTYEAR FUNDING ESTIMATES
(BA in thousands)

	FY10 & Prior	FY11	FY12	FY13	FY14	FY15	Cost to Complete	Total
Joint Polar Satellite System	2,908,494	1,060,800	1,160,000	960,000	740,000	610,000	4,489,506	11,928,800

Proposed JPSS Organization

NOAA Under Secretary
Deputy Under Secretary
NESDIS Assistant Administrator

NASA/SMD Joint-Agency Satellite Division

Division Director (NASA) - Marcus Watkins
Program Director (NOAA) – Gil Colon, Acting
Program Scientist (NOAA) – Karen St.Germain, Acting

7120.5 Compliant Organization

Program Office
Program Manager (NASA) – P. Burch
Deputy Program Manager (NASA) – E. Citrin
NOAA Team Member (NOAA) - TBD
Business Manager (NASA) – L. Greenslade
Chief Engineer (NASA) – A. Whipple
Senior Project Scientist (NASA) – J. Gleason

Goddard Space Flight Center (GSFC) On-Site

Decision Councils

Agency-level PMC
NASA/NOAA co-chair

SMD/NESDIS PMC
NASA/NOAA co-chair

Joint NASA/NOAA
Center Mgmt Council

DOD
NPOESS
AM Program

Finance
Financial Manager (NASA) – TBD

Program Mission Assurance
Chief Safety & Mission Assurance Officer (NASA)

Procurement
Lead Contracting Officer (NASA) – S. Marshall

Flight Project
Project Manager (NASA – K. Schwer)
Deputy Project Manager (NASA) – R. Lilly
Deputy Project Manager (NASA) – P. Sullivan
NOAA Team Member (NOAA) - TBD

Ground Project
Project Manager (NASA) – D. Devito
Deputy Project Manager (NOAA) – T. Zeiler
DPM for Development and I&T (NASA) – J. Smith

JPSS Transition Summary

- NOAA/NASA committed to working with DOD to ensure an efficient and effective transition
- NOAA/NASA stand ready to lead transition team
- NOAA/NASA Acquisition and legal teams have already initiated procurement transition strategies
- The afternoon orbit is NOAA's top priority – it is critical for work to continue seamlessly through this transition

Questions?

Current Launch Readiness Date:
September 23, 2011

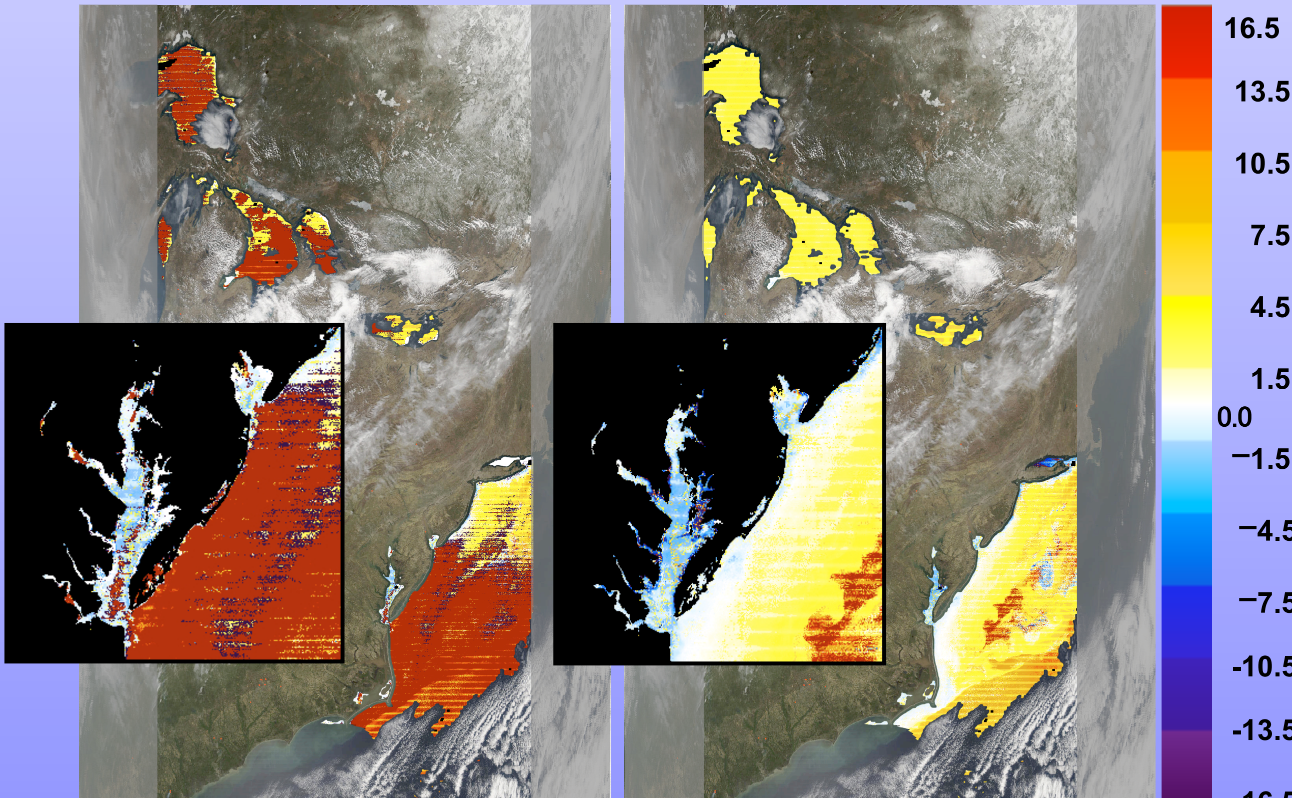
LRD: No earlier than 15.5 months after delivery of last instrument:
Launch NET Late Oct 2011

View of NPP from Back of Spacecraft

Photo Courtesy of Ball Aerospace

VIIRS EDR Performance: Ocean Color Performance Cross talk

NPP Chl-a **OCM3 Chl-a**



A20051071815 - East USA

17 April 2005

Relative Difference (%)

"However, we are optimistic that the VIIRS instrument may still be a viable ocean color instrument, provided that the calibration and validation infrastructure of heritage NASA EOS missions is in place. This infrastructure includes a plan and support for vicarious calibration site(s), a data/validation program, on-orbit calibration maneuvers, regular mission-level data reprocessing, and the use of NASA selected operational algorithms."

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 $NE\Delta T$ (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 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**

VIIRS 24 EDRs

Land, Ocean, Atmosphere, 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 has a Key Performance attribute

NASA's NPP Science Role

- **Climate data record (CDR): "a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change." (NRC: CDRs from Env. Sat. 2004)**
  - **"CDR" Definition of Consistent:**
    - **all temporal sensor artifacts removed**
    - **no obvious interannual discontinuities unattributable to natural variability**
    - **all known mission-dependent biases removed or quantified**
    - **similar data quality and structure**
- **The NPP Science Charter is to: *Continue the scientific data record started in the "EOS era."***
- **NICST/E Group to remove "all temporal sensor artifacts"**
- **NPP Science Team to "quantify and remove all known mission-dependent biases" removed or quantified and to provide similar data quality and structure"**
- **Reprocessing will be required to produce Consistent, Integrated EOS/NPP/NPOESS Satellite data records.**

Mission Success

- **The NPP Mission Success is determined by its capabilities**
  - **to provide continuation of a group of earth system observations initiated by the Earth Observing System (EOS) Terra, Aqua and Aura missions and**
  - **by its ability to reduce the risks associated with its advance observational capabilities as they are being transitioned from the NASA research program into the NPOESS operational program in support of both the Department of Defense (DoD) and NOAA**
    - These include pre-operational risk reduction demonstration and validation for selected NPOESS instruments, and algorithms, as well as ground data processing, archive and distribution.

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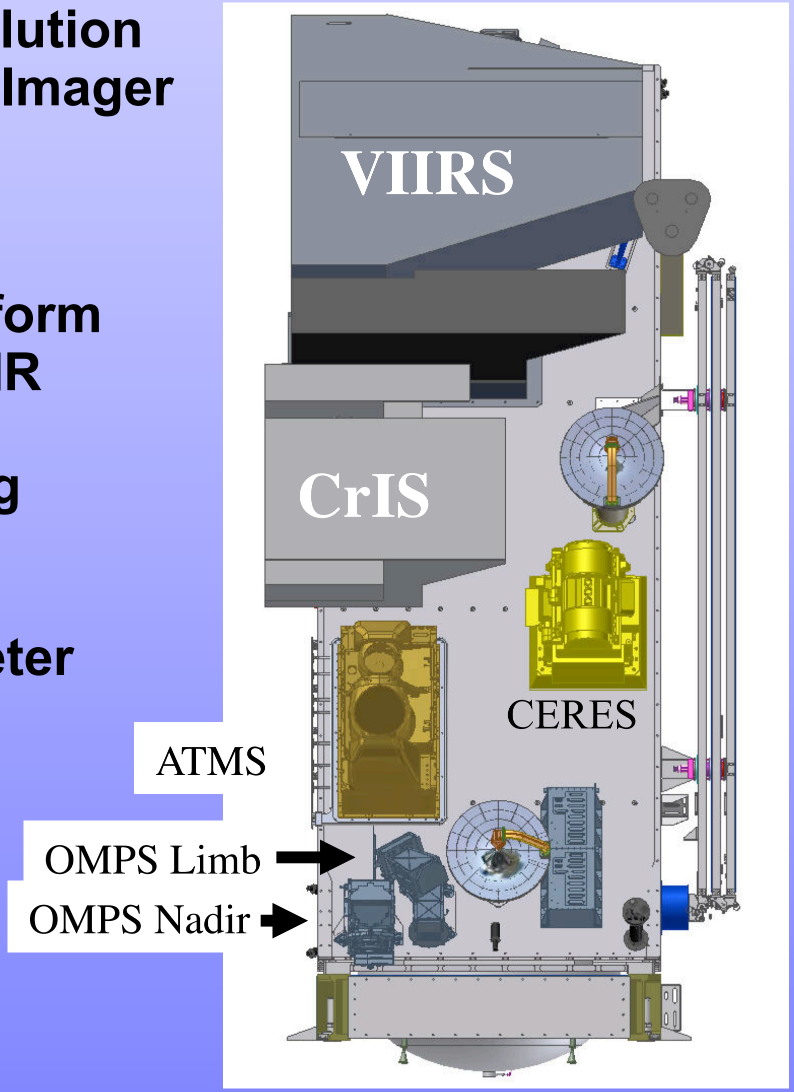

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