The NPOESS Spacecraft and Payload Suite A Next Generation Low Earth Orbit Observation Platform

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The National Polar-orbiting Operational Environmental Satellite System (NPOESS) and its managing Integrated Program Office (IPO) were established by a 1994 Presidential Decision Directive to converge existing Air Force, NASA & NOAA polar-orbiting satellites into an integrated national program. It is the follow on mission to the TIROS and DMSP satellites, carrying the next generation of weather instruments. NPOESS will exemplify the capabilities and challenges of future low earth orbit weather observation spacecraft.

Earth observing requirements from the weather and climate science communities have significantly increased the demands on spacecraft. Increases in the number of phenomena observed, increases in their resolution and accuracy, and shorter refresh and reporting times put significant demands on spacecraft and ground systems. The impact of these new requirements on spacecraft are more instruments, high accuracy stable spacecraft platforms with higher data rates and more frequent data communications to the ground.

To meet user-validated requirements for 55 geophysical parameters as shown in Figure 1, NPOESS will deliver global Stored Mission Data (SMD) to four U.S. centers for processing and distribution, with 95% of the data being delivered in less than 28 minutes from the time of collection.

The advanced technology visible, infrared, and microwave imagers and sounders that will fly on NPOESS will deliver higher spatial and temporal resolution atmospheric, oceanic, terrestrial, climatic, and solar-geophysical data, enabling more accurate short-term weather forecasts and severe storm warnings, as well as serving the data continuity requirements for improved global climate change assessment and prediction. The NPOESS team (IPO, Northrop Grumman, and its subcontractors) is well along the path to creating a high performance, polar-orbiting satellite system that will be more responsive to user requirements, deliver more capability at less cost, and provide sustained, space-based measurements as a cornerstone of an Integrated Global Observing System.

☆ Atmospheric Vertical Moisture Profile	Cloud Top Pressure	Precipitable Water
☆ Atmospheric Vertical Temp Profile	Cloud Top Temperature	Precipitation Type/Rate
☆ Imagery	Downward Longwave Radiance (Sfc)	Pressure (Surface/Profile)
☆ Sea Surface Temperature	Downward Shortwave Radiance(Sfc)	Sea Ice Characterization
☆ Sea Surface Winds	Electric Field	Sea Surface Height/Topography
☆ Soil Moisture	Electron Density Profile	Snow Cover/Depth
Aerosol Optical Thickness	Energetic Ions	Solar Irradiance
Aerosol Particle Size	Geomagnetic Field	Supra-Thermal-Auroral Particles
Aerosol Refractive Index	Ice Surface Temperature	Surface Type
Albedo (Surface)	In-*situ* Plasma Fluctuations	Wind Stress
Auroral Boundary	In-*situ* Plasma Temperature	Suspended Matter
Auroral Energy Deposition	Ionospheric Scintillation	Total Water Content
Auroral Imagery	Medium Energy Charged Particles	Vegetation Index
Cloud Base Height	Land Surface Temperature	
Cloud Cover/Layers	Net Heat Flux	
Cloud Effective Particle Size	Net Solar Radiation (TOA)	
Cloud Ice Water Path	Neutral Density Profile	
Cloud Liquid Water	Color/Chlorophyll	
Cloud Optical Thickness	Ocean Wave Characteristics	
Cloud Particle Size/Distribution	Outgoing Longwave Radiation (TOA)	
Cloud Top Height	Ozone - Total Column/Profile	

VIIRS (23)
CMIS (19)
CrIS/ATMS (3)
OMPS (1)
SES (13)
GPSOS (2)
ERBS (5)
TSIS (1)
ALTIMETER (3)
APS (4)

☆ Environmental Data Records (EDRs) with Key Performance Parameters

Figure 1. NPOESS EDR-to-Sensor Mapping. 55 Product Sets [RDR, SDR, EDR]

The agencies participating in the NPOESS program have agreed upon a fully defined set of Integrated Operational Requirements , in a document called the IORD, that will meet the needs of the civil and military users of satellite data. These established requirements for the 55 atmospheric, oceanic, terrestrial, and solar-geophysical data products are guiding the development of the advanced technology microwave, visible and infrared sounders and imagers that will provide enhanced capabilities and improve the accuracy and timeliness of observations.

In this paper we will discuss the critical sensors that contribute to the key performance parameters listed in Figure 1.

flown on DMSP. The VIIRS will provide imagery of clouds under sunlit conditions in about a dozen visible channels (or frequency bands), as well as provide coverage in a number of infrared channels for night and day cloud imaging applications. VIIRS will have multichannel imaging capabilities to support the acquisition of high resolution atmospheric imagery and generation of a variety of applied products including: visible and infrared imaging of hurricanes and detection of fires, smoke, and atmospheric aerosols. VIIRS will also provide capabilities to produce higher resolution and more accurate measurements of sea surface temperature than currently available from the heritage AVHRR instrument on POES, as well as an operational capability for ocean color observations and a

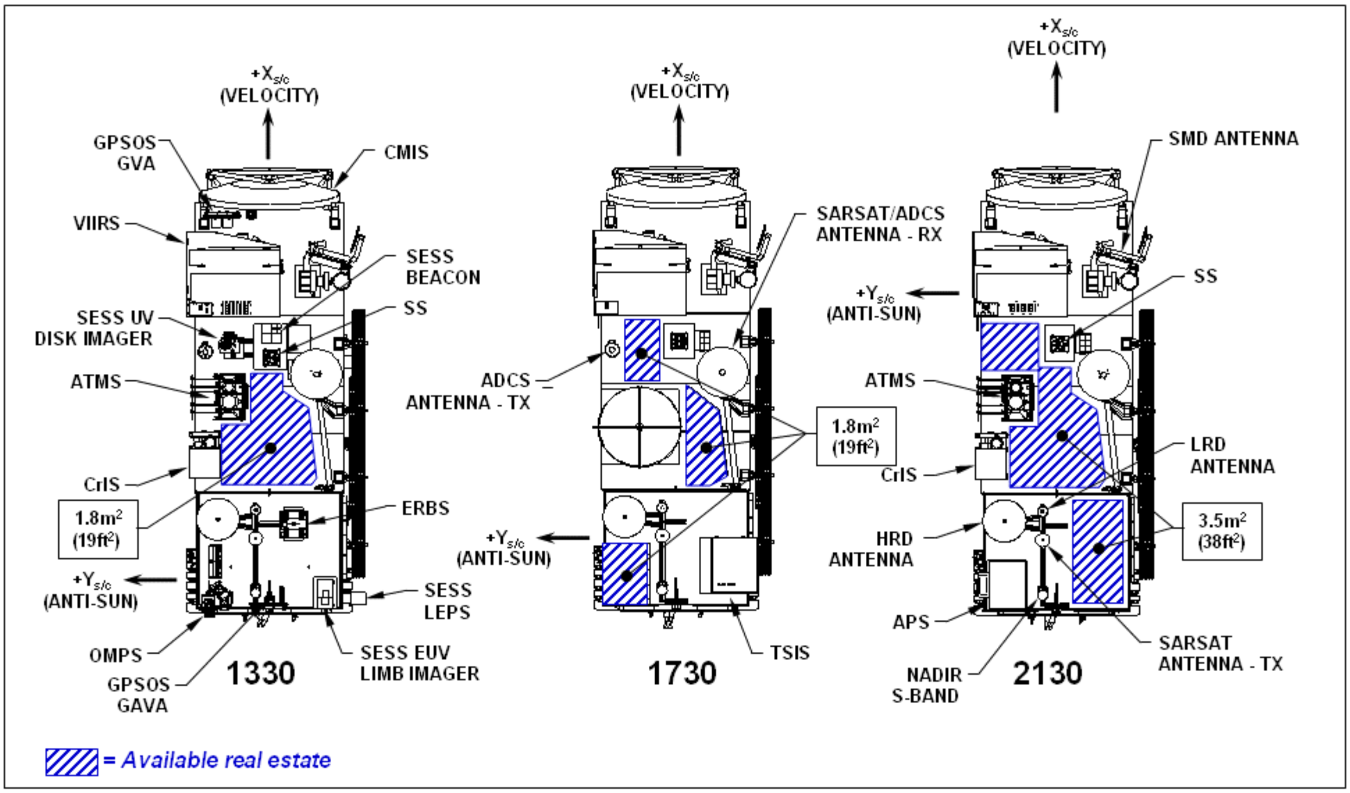

Figure 2. NPOESS satellites. Satellite has room for growth, but considerations are needed for FOV, area, and other issues.

The Space Segment is a three-orbit plane, with one satellite for each orbit plane constellation (1330, 1730 and 2130 LTAN). Each orbit plane will contain a unique set of sensor complements (Figure 2).

The Visible Infrared Imager / Radiometer Suite (VIIRS) is a close cousin of the EOS MODIS instrument and will combine the radiometric accuracy of the Advanced Very High Resolution Radiometer (AVHRR) currently flown on the NOAA polar orbiters with the high (0.65 kilometer) spatial resolution of the Operational Linescan System (OLS)

variety of derived ocean color products. VIIRS accommodated on all three orbits.

The Conical Scanning Microwave Imager/Sounder collects global microwave radiometry and sounding data to produce microwave imagery and other meteorological and oceanographic data. CMIS collects microwave radiometry and sounding data. Data types include atmospheric temperature and moisture profiles, clouds, sea surface winds, and all-weather land/water surfaces. CMIS contributes to 23 Environmental Data Records

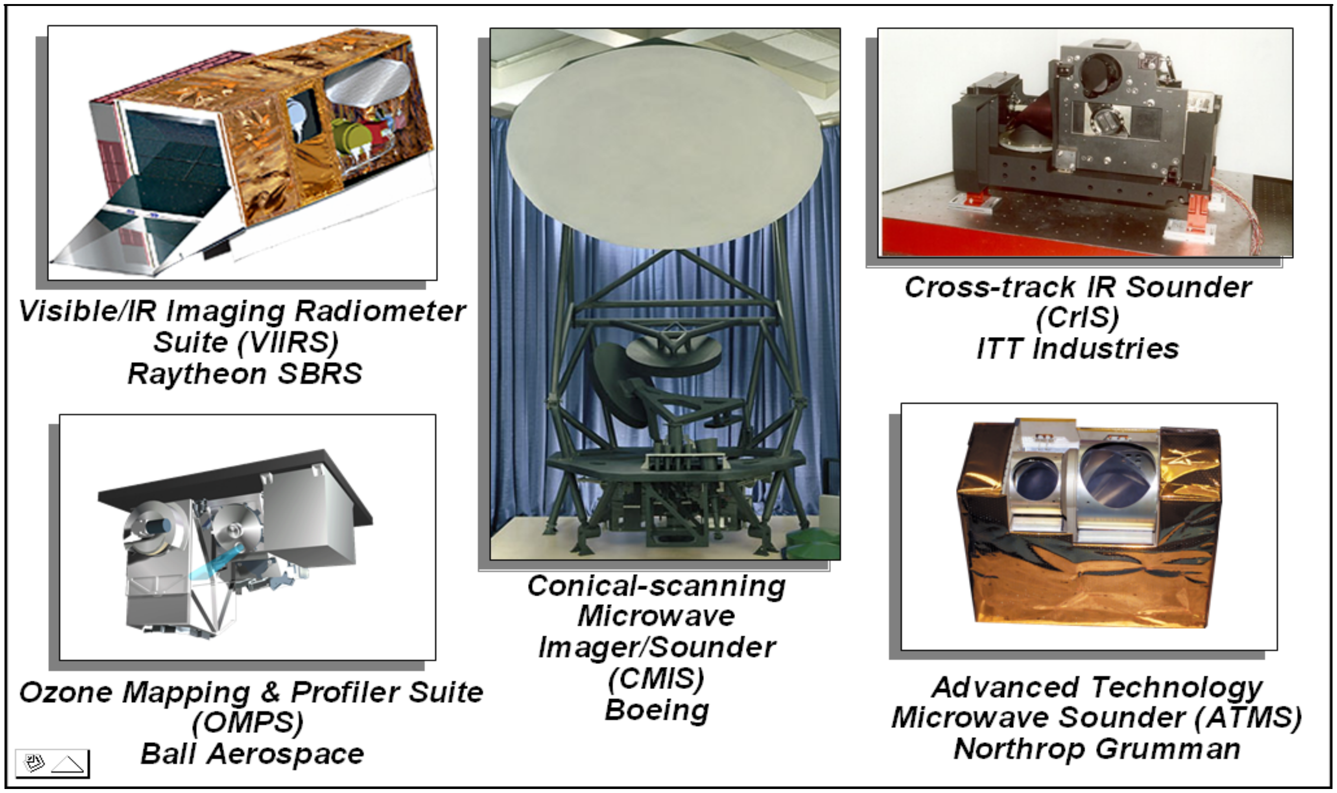

Figure 3. Key Sensors Under Development at or Near CDR Level

(EDRs) and is the primary instrument for 9 EDRs. CMIS is the follow on to SSM/IS and is a key NPOESS sensor that will be accommodated on all three orbits. In conjunction with the Advanced Technology Microwave Sounder (ATMS) the Cross-track Infrared Sounder collects atmospheric data to permit the calculation of temperature and moisture profiles at high (~ daily) temporal resolution.

Both CrIS and ATMS (CrIMSS) are selected to fly on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) spacecraft combining both cross-track infrared and microwave sensors aboard the NPOESS satellite. The CrIMSS is the replacement for the operational HIRS/AMSU suite of instruments.

The Cross-track Infrared Sounder (CrIS) provides improved measurements of the temperature and moisture profiles in the atmosphere. Forecasters use temperature and moisture sounding data in advanced numerical weather prediction models to improve both global and regional predictions of weather. The current High-resolution Infrared Radiation Sounder (HIRS) instrument on POES provides about 20 infrared channels of information and is able to characterize atmospheric temperature profiles to an accuracy of 2 to 3 degrees Kelvin. Modern and future forecast models demand higher accuracy. The CrIS will provide this by enhancing the vertical and horizontal spatial resolution to measure temperature profiles with improved vertical resolution to an accuracy approaching one degree Kelvin. This improved accuracy is needed for increasingly sophisticated forecase models. CrIS and ATMS will fly in the 1330 and 2130 orbits.

The Ozone Mapping and Profiler Suite (OMPS) monitors ozone from space. OMPS will collect total column and vertical profile ozone data and continue the daily global data produced by the current ozone monitoring systems, the Solar Backscatter Ultraviolet radiometer (SBUV)/2 and Total Ozone Mapping Spectrometer (TOMS), but with higher fidelity. The collection of this data contributes to fulfilling the U.S. treaty obligation to monitor the ozone depletion for the Montreal Protocol to ensure no gaps on ozone coverage. The nadir sensor uses a wide field-of-view push-broom telescope to feed two separate spectrometers. The nadir total column spectrometer (mapper) measures the scene radiance between 300 and 380 nanometers (nm) with a resolution of 1 nm sampled at 0.42 nm and a 24-hour ground revisit time. Measurements from this spectrometer are used to generate total column ozone data with better than 50 x 50 km resolution at nadir. The nadir profile spectrometer measures between 250 and 310 nm with the same spectral sampling, in a single ground pixel of 250 x 250 km. The limb sensor measures the along-track limb scattered solar radiance with 1 km vertical sampling in the spectral range of 290 to 1000 nm. The OMPS will be flying in the 1330 orbit.