NPOESS - A Future Space Weather Monitoring Platform

by

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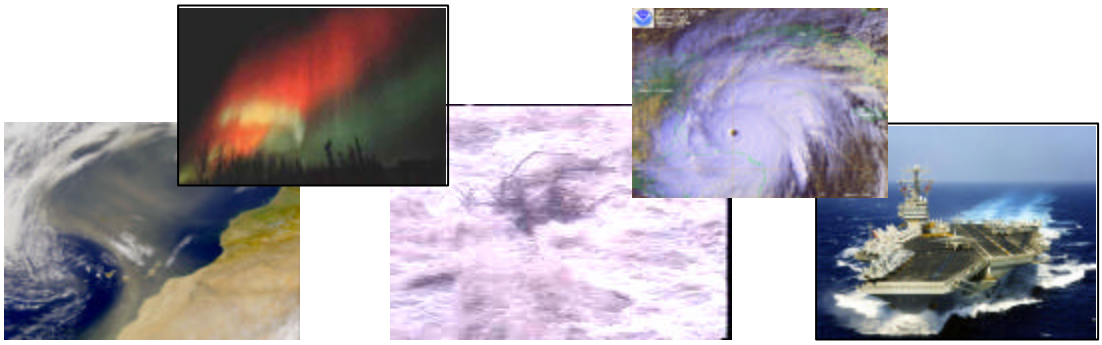
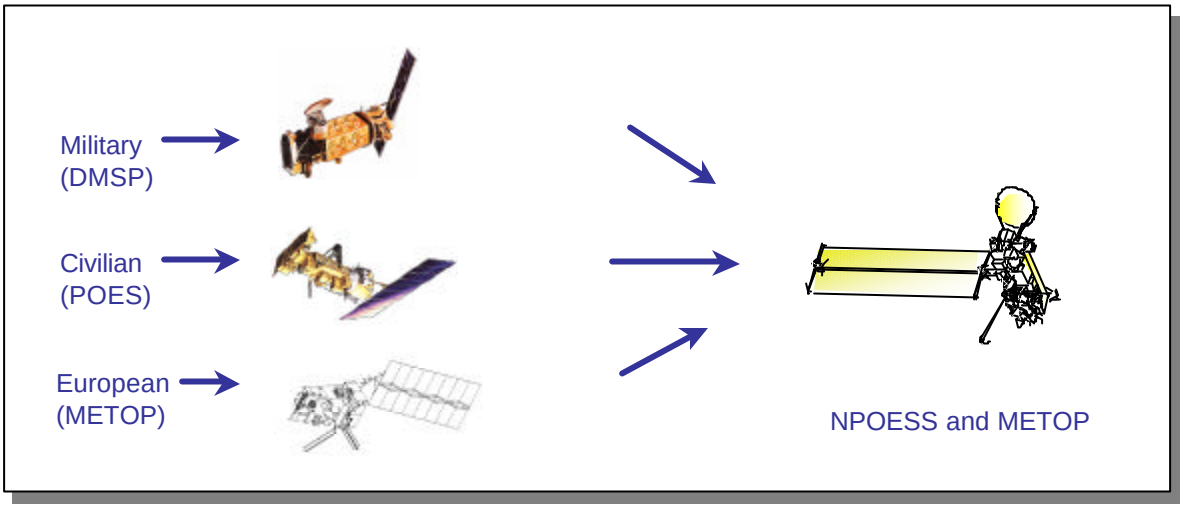
The National Polar-orbiting Operational Environment Satellite System (NPOESS) is the next-generation low-earth orbiting system for space-based environmental monitoring for the U.S.A. The NPOESS is the converged system that will replace the current Defense Meteorological Satellite Program (DMSP) and the Polar-orbiting Operational Environment Satellite (POES) in the latter part of the current decade. Currently, the DMSP serves the needs of the military for space-based weather monitoring whereas the POES serves the needs of the civilian agencies. A key function of the NPOESS is to monitor the space environment across a broad range of measurable parameters, each of which is commonly referred to as an Environmental Data Record (EDRs). The Integrated Program Office (IPO) for the NPOESS is responsible for satisfying the stated requirements for space environmental EDRs that are detailed in the Integrated Operational Requirements Document (IORD). The instrument complement for the NPOESS spacecraft that has been assigned responsibility for addressing the space EDRs is the Space Environment Sensor Suite (SESS). In order to gain a better understanding of User needs as they relate to the SESS requirements the IPO has conducted several studies during the past few years the products of which are publicly available on the WWW. The intent of this presentation, which is derived from the available documentation, is to inform the community as to the current state of the SESS from a standpoint that includes both the requirements and a preliminary functional description.

NPOESS DESCRIPTION

NPOESS is required to provide an OPERATIONAL remote sensing capability to acquire and receive in real-time at field terminals, and to acquire, store and disseminate to processing centers, GLOBAL and regional environmental imagery and specialized METEOROLOGICAL, CLIMATIC, TERRESTRIAL, OCEANOGRAPHIC and SOLAR-GEOPHYSICAL and other data in support of CIVILIAN and NATIONAL SECURITY missions

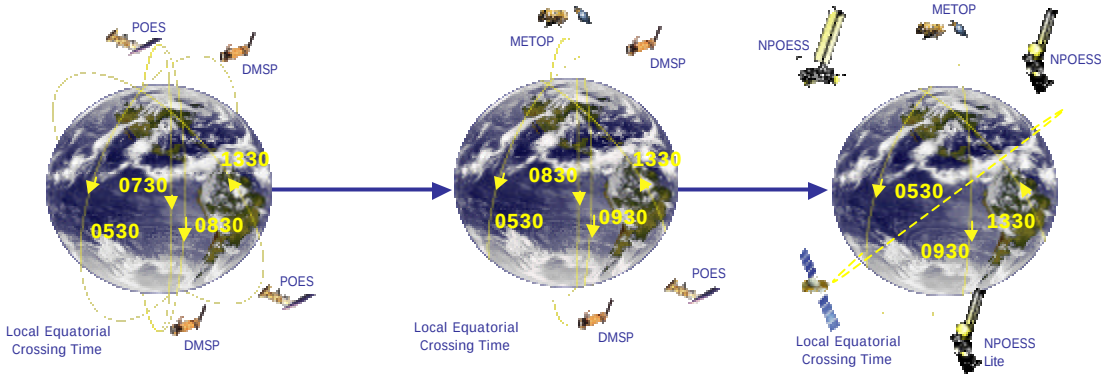


CONVERGENCE



NPOESS convergence refers to the merging of the distinct DMSP and POES systems into a single U.S. space-based weather monitoring platform. European participation (METOP) is considered an element of the full system.

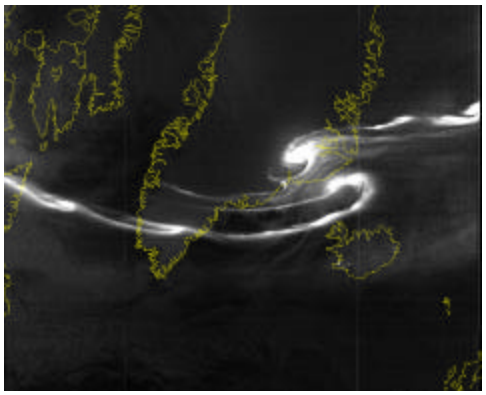
NPOESS EVOLUTION



Today	Tomorrow (2005)	Future (2013)
• 4-Orbit System	• 4-Orbit System	• 3-Orbit System
–2 US Military	–2 US Military	–2 US Converged
–2 US Civilian	–1 US Civilian	–1 US “Lite”
	–1 METOP	–1 METOP
		–Specialized Satellites

SPACE ENVIRONMENTAL SENSOR SUITE

SESS measures the near-Earth space environment in terms of neutral and charged particles, electric and magnetic fields, and optical signatures of aurora. Primary sensor suite for satisfying 14 EDRs.



Functional Specification

Multiple sensors required to measure and process a divergent set of space environmental EDRs

Heritage Sensors

DMSP Special Sensors

POES Space Environment Monitor

SPACE ENVIRONMENT
USER NEEDS ASSESSMENT

USER: DOD	USER NEED
Radar Operations	*Solar noise*, auroral clutter specification
	Range error correction, scintillation
HF Communications	MUF/FOT, PCA event, shortwave fades
Navigation/Satellite Comm.	Single frequency GPS accuracy
	Scintillation forecast/specification
Classified	Arbitrary slant path TEC
Altimetry, Single Frequency	Ionospheric corrections for sea surface heights
Satellite Design and Anomaly	Radiation hazards for manned spaceflight & high flyers
	Long-term representative data sets for satellite design
	Space environment data for anomaly resolution
Space Surveillance	Accurate neutral density forecast/specification

USER: DOC	USER NEED
Satellite Operators	Space environmental parameters affecting satellite ops
Power Companies	*Distribution and intensity of geomagnetic field variations*
NASA	Radiation dose(man) , polar cap boundary, satellite drag
FAA	Ionospheric impacts on communications and navigation
NOAA	Radiation effects on satellite, mag field variations, drag
Ham Radio Operators	Global ionospheric disturbances
Geo-Prospecting	Locations of geomagnetic field variations
Science Community	Space environment effects on experiments, contamination
Intl Forecast Cntrs (Japan. Australia, etc)	Global situational awareness

USER: NASA	USER NEED
Manned Spaceflight	Radiation Dose
Satellite Lifetimes	Orbital drag forecasts

Note: User need in ***red italics*** are not addressed by NPOESS

Product of the Space Environment Steering Group, 01 Dec 99
SESG report available at http://npoesslib.ipo.noaa.gov/S_sess.htm

NPOESS SPACE ENVIRONMENTAL DATA RECORDS

- Auroral Boundary
- Auroral Energy Deposition
- Auroral Imagery
- Electric Field
- Electron Density Profile
- Geomagnetic Field
- In-situ Plasma Fluctuations
- In-situ Plasma Temperature – T_e & T_i
- Ionospheric Scintillation
- Neutral Density Profile
- Medium Energy Charged Particles
- Energetic Ions
- Supra-thermal through Auroral Energy Particles
- Neutral Winds (Pre-planned Product Improvement)

Each EDR is Specified in the NPOESS Technical Requirements Document (TRD)

Example: Medium Energy Charged Particles

		Threshold	Objective
40.8.16-1	a. Horizontal Reporting Interval	10 km	5 km
40.8.16-2	b. Horizontal Coverage	>30º latitude, N/S	>30º latitude, N/S
	c. Measurement Range (e & ions)		
40.8.16-3	1. Particle Energy	30 eV - 50 keV	30 eV - 50 keV
	2. Flux		
40.8.16-4	a. electrons	10^9 - 10^{14} m^{-2} s^{-1} $ster^{-1}$	10^9 - 10^{14} m^{-2} s^{-1} $ster^{-1}$
40.8.16-15	b. ions	10^9 - 10^{13} m^{-2} s^{-1} $ster^{-1}$	10^8 - 10^{13} m^{-2} s^{-1} $ster^{-1}$
40.8.16-5	3. Sensor viewing angles	0º & 90º (2 angles)	0º – 90º (multiple angles)
40.8.16-16	4. Particle energy resolution	24 log-periodic energy bands	32 log-periodic energy bands
	d. Measurement Precision		
40.8.16-6	1. Deleted		
40.8.16-7	2. Diff.directional energy flux	Max {10^9 m^{-2} s^{-1} $ster^{-1}$, 10%}	Max {10^8 m^{-2} s^{-1} $ster^{-1}$, 2%}
40.8.16-8	3. Sensor FOV	<15º	<15º
	e. Measurement Accuracy		
40.8.16-9	1. Pass Band Center Energy	2%	1%
40.8.16-10	2. Diff. Dir Energy Flux	Greater of {15%, 10^9 m^{-2} s^{-1} $ster^{-1}$}	Greater of {10%, 10^9 m^{-2} s^{-1} $ster^{-1}$}
40.8.16-11	3. Sensor Field-of-View	<3º	<3º
40.8.16-12	f. Measurement Uncert. – Energy	20%	15%
	g. Deleted		
40.8.16-13	1. Deleted		
40.8.16-14	2. Deleted		
40.8.16-17	h. Latency (Data Latency)	90 minutes	15 minutes

Example - complete specification contained in the NPOESS TRD
The TRD is available at http://npoesslib.ipo.noaa.gov/

EDR Mapping to Notional Sensors

EDR	GPS Occultation	Radio Beacon	Ultraviolet Imager	RPA / Langmuir Probe	Driftmeter / Cold Ion Trap	Magnetometer	Electostatic Analyzer	Fabry Perot Interferometer	Solid State Detector
Auroral Boundary			P				P		
Auroral Energy Deposition			S				P		
Auroral Imagery			P					S	
Electric Field					P				
Electron Density Profile	P	S	S	S					
Geomagnetic Field						P			
In-situ Plasma Fluctuations					P				
In-situ Plasma Temperature				P					
Ionospheric Scintillation	S	P							
Neutral Density Profile			P						
Medium Energy Charged Particles									P
Energetic Ions									P
Supra-thermal to Auroral Energy Particles							P		
Neutral Winds (P^3I)								P	

P = Primary Sensor
S = Supporting Sensor

Product of the SESS Government Advisory Team, 04 May 01
GAT report available at http://npoesslib.ipo.noaa.gov/S_sess.htm

SUMMARY

The SESS for the NPOESS mission offers to be the most comprehensive operational monitor of the near-Earth space environment available during the time frame 2010 through 2020. The SESS is a fundamental element of the future Space Weather program from the National Security Space Architect and from the Office of the Federal Coordinator for Meteorology. The requirements for the SESS have been are consistent with current User needs and the perceived need of future Users. These requirements are defined in the NPOESS Integrated Operational Requirements Document and, more specifically, in the NPOESS TRD. Background data and current requirement specifications are available on the WWW. Developmental and acquisition responsibility for the SESS are to be included in the overall NPOESS system procurement.

Presented at the Space Weather Effects on Communications and Navigation Signals, Boston College, 7-8 June 2001.