NPOESS
National Polar-orbiting Operational Environmental Satellite System
NPOESS Introductory Video
Tri-agency Effort to Leverage and Combine Environmental Satellite Activities

**Mission**

- Provide a national, operational, polar-orbiting remote-sensing capability
- Achieve National Performance Review (NPR) savings by converging DoD and NOAA satellite programs
- Incorporate new technologies from NASA
- Encourage international cooperation
Building A More Capable System
The Historical Context

First Image from TIROS-1
(Early 60s)

EOS-Aqua MODIS Image-250 m

Saharan Dust off the Canary Islands
18 February 2004
NPOESS Requirements

- Integrated Operational Requirements Document (IORD-I)
  - 59 Data Products
  - 9 Enhancement Products
  - 1 System Characteristic Key Performance Parameter (KPP)
- Validated by Joint Agency Requirements Committee (JARC) JARC 1996
- IORD-II
  - 55 Data Products
  - 21 Enhancement Products
  - 2 System Characteristic KPPs
- Validated by Dec 2001

Converged Requirements Provide Foundation for Combined Program
NPOESS Overview System Architecture

**Space Segment**
- NPP (1030)
- 1330, 1730, 2130, Residuals, NPOESS Spacecraft
- GPS
- TDRSS

**C3 Segment**
- Svalbard Primary T&C
- NPP SMD
- White Sands Complex LEO & A Backup T&C
- 15 Globally Distributed Receptor Sites Interconnected by Commercial Fiber

**Launch Support Segment**
- Schriever MMC
- Contingency Operations Team

**Field Terminal Segment**
- Interface Data Processing Segment
  - One full set resides in each of the 4 Centrals

**Data Handling Node**
- One full set resides in each of the 4 Centrals
- Command and Telemetry

- NPOESS Stored Mission Data
- NPP Stored Mission Data

- ADCS
- SARSAT
- HRO Field Terminal
- LRD Field Terminal
- CLASS
- ADS
- SDS
- NAVO
- FNMOC
- AFWA
- NESDIS

**MMC at Suitland Mission Operations Team**
- Enterprise Management
- Mission Management
- Satellite Operations
- Data Monitoring & Recovery
## NPOESS Satellite and Sensors

### Single Satellite Design with Common Sensor Locations and “ring”

Data Bus Allows Rapid Reconfiguration and Easy Integration
NPOESS EDR-to-Sensor Mapping

NPOESS EDR-to-Sensor Mapping
(55 EDRs, 9 Sensors)

CMIS
(19)
- CLOUD BASE HEIGHT
- Ice Surface Temperature
- IMAGERY
- LAND SURFACE TEMP
- Sea Ice Characterization
- SNOW COVER/DEPTH
- SURFACE TYPE
- SEA SURFACE TEMPERATURE
- SOIL MOISTURE

CrIS/ATMS
(3)
- ATM VERT MOIST PROFILE
- ATM TEMP PROFILE
- PRESSURE (SURFACE/PROFILE)

VIIRS
(22)
- AEROSOL OPTICAL THICKNESS
- AEROSOL PARTICLE SIZE

APS *
(4)
- Aerosol Refractive Index, Single Scatter Albedo, Shape
- Cloud Particle Size/Distrib

OMPS
(1)
- O3 Total Column (also CrIS)

TSIS
(1)
- Solar Irradiance

Key:
- Undeclared = NPP EDRs (25)
- = NPOESS Key Performance Parameters
- BOLD CAPS = LRO Environmental Data Records
- * = not yet on contract

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IREBS
(4)
- Down LW Radiance (Sfc)
- Down SW Radiance (Sfc)
- Net Solar Radiation (TOA)
- Outgoing LW Rad (TOA)

NPOESS EDR-to-Sensor Mapping

29 Dec 2004
DOQG, NCGA, NCRGS,
Integrated Program Office
D. Plata, M. Haas, S. Mango,
J. Schaefer, J. Wilcomb

NPOESS MISSION AREAS
- Atmosphere
- Climate
- Land
- Ocean
- Space Environment
Development Sensor Highlights

• Visible/Infrared Imager Radiometer Suite (VIIRS)
  Raytheon Santa Barbara
  – 0.4 km imaging and 0.8 km radiometer resolution
  – 22 spectral bands covering 0.4 to 12.5 \( \mu \text{m} \)
  – Automatic dual VNIR and triple DNB gains
  – Spectrally and radiometrically calibrated
  – EDR-dependent swath widths of 1700, 2000, and 3000 km

• Crosstrack InfraRed Sounder (CrIS)
  ITT Ft Wayne
  – 158 SWIR (3.92 to 4.64 \( \mu \text{m} \)) channels
  – 432 MWIR (5.71 to 8.26 \( \mu \text{m} \)) channels
  – 711 LWIR (9.14 to 15.38 \( \mu \text{m} \)) channels
  – 3x3 detector array with 15 km ground center-to-center
  – 2200 km swath width
VIIRS Data Collection
Development Sensor Highlights (Continued)

• Advanced Technology Microwave Sounder (ATMS) - NASA
  
  **Northrop Grumman Electronics**
  – CrIS companion cross track scan
  – Profiling at 23, 50 to 57, 183 GHz
  – Surface measurements at 31.4, 88, 165 GHz
  – 1.1, 3.3, and 5.2 deg (SDRs resampled)
  – 2300 km swath width

• Ozone Mapping and Profiler Suite (OMPS)
  
  **Ball Aerospace**
  – Total ozone column 300 to 380 nm with 1.0 nm resolution
  – Nadir ozone profile 250 to 310 nm with 1.0 nm resolution
  – Limb ozone profile 290 to 1000 nm with 2.4 to 54 nm resolution
  – Swath width of 2800 km for total column
OMPS Data Collection
• Conical Scanning Microwave Imager/Sounder (CMIS)

**Boeing Space Systems**
- 2.2 m antenna
- RF imaging at 6, 10, 18, 36, 90, and 166 GHz
- Profiling at 23, 50 to 60, 183 GHz
- Polarimetry at 10, 18, 36 GHz
- 1700 km swath width
CMIS Data Collection
Leverage Sensor Highlights

• Radar Altimeter (ALT)
  
  **Alcatel**
  – Measures range to ocean surface with a radar at 13.5 GHz
  – Corrects for ionosphere with 5.3 GHz radar
  – Corrects for atmosphere with CMIS water vapor measurements
  – Precise orbit determination with GPS

• Earth’s Radiation Budget Suite (ERBS)
  
  **Northrop Grumman Space Technology**
  – Three spectral channels
  – Total radiation measurement 0.3 to 50 μm
  – Shortwave Vis and IR measurement 0.3 to 5 μm
  – Longwave IR measurement 8 to 12 μm
Leverage Sensor Highlights (Continued)

• Total Solar Irradiance Sensor (TSIS)
  
  University of Colorado
  – Two sensors for total irradiance (TIM) & spectral irradiance (SIM)
    ▪ TIM measures total solar irradiance
    ▪ SIM measures spectral irradiance 200 to 2000 nm
  – Pointing platform and sensor suite to be provided by CU LASP
Highlights of Other Sensors

• Space Environment Sensor Suite (SESS)
  
  **Ball Aerospace**
  
  – Sensor suite collecting data on particles, fields, aurora, and ionosphere
  – Suite includes a UV disk imager (BATC), charged particle detectors (Amptek/U. of Chicago), thermal plasma sensors (UTD)
  – Will distribute suite on all 3 orbital planes

• Advanced Data Collection System (ADCS) and Search and Rescue Satellite-Aided Tracking (SARSAT)
  
  – “GFE” to NPOESS from France and China
  – ADCS supports global environmental applications
  – SARSAT collects distress beacon signals
• Aerosol Polarimetry Sensor (APS)

Raytheon Santa Barbara Remote Sensing

– Aerosol characterizations of size, single scattering albedo, aerosol refractive index, aerosol phase function
– Multispectral (broad, 0.4 to 2.25 μm)
– Multiangular (175 angles)
– Polarization (all states)
Atmospheric Vertical Temperature Profile

Highly accurate measurement of the vertical distribution of temperature in the atmosphere in layers from the surface to 0.01 mb

**Systems Capabilities**

- **Horizontal Cell Size**
  - Clear, nadir: 18.5 km
  - Clear, worst case: 100 km
  - Cloudy, nadir: 40 km
  - Cloudy, worst case: 50 km

- **Vertical Reporting Interval**
  - Surface to 850 mb: 20 mb
  - 850 to 300 mb: 50 mb
  - 300 to 100 mb: 25 mb
  - 100 to 10 mb: 20 mb
  - 10 to 1 mb: 2 mb
  - 1 to 0.1 mb: 0.2 mb
  - 0.1 to 0.01 mb: 0.02 mb

- **Mapping Accuracy**
  - 5 km

- **Measurement Uncertainty** (expressed as error in layer average temperature)**:
  - Clear:
    - Surface to 300 mb*: 1.6 K per 1 km layer
    - 300 mb to 30 mb: 1.5 K per 3 km layer
    - 30 mb to 1 mb: 1.5 K per 5 km layer
    - 1 mb to 0.01 mb: 3.5 K per 5 km layer
  - Cloudy:
    - Surface to 700 mb*: 2.5 K per 1 km layer
    - 700 mb to 300 mb: 1.5 K per 1 km layer
    - 300 mb to 30 mb: 1.5 K per 3 km layer
    - 30 mb to 1 mb: 1.5 K per 5 km layer
    - 1 mb to 0.01 mb: 3.5 K per 5 km layer

- **Latency**: 156 minutes
- **Refresh**: 6 hours
- **Long-Term Stability***
  - Trop. Mean: 0.05 K
  - Strat. Mean: 0.10 K

**Thresholds**

- 1 km
- 10 mb
- 0.1 mb
- 0.5 km
- 0.5 K

**Objectives**

- 1 km
- 10 mb
- 0.1 mb
- 0.5 K

**Major Applications**

1) Initialization of Numerical Weather Prediction Models
2) Complementary data for derivation of moisture/pressure profiles and cloud properties

Iterative, Disciplined Requirements Process Ensures Users Needs are Met
Program Schedule

2002  A&O Contract Award
2003  NPP Delta Critical Design Review
2005  NPOESS ΔPreliminary Design Review
2007  NPOESS Critical Design Review
      NPP Ground Readiness
2008  NPP Launch (TBR)
2009  NPOESS Ground Readiness
2010  NPOESS C1 Launch (TBR)
2011  NPOESS C2 Launch (TBR)
      Field Terminal Segment Readiness
      Initial Operational Capability
2013  NPOESS C3 Launch
2015  NPOESS C4 Launch
2017  NPOESS C5 Launch
2020  End of Program

Reliable and timely collection, delivery, and processing of quality environmental data
SafetyNet* – The Key to Low Data Latency and High Data Availability

More than 75% of NPOESS Data Products at the Nation’s Weather Centrals within 15 min..........95% in under 30 min

* NGST Patent Pending
NPOESS SafetyNet* Design

* NGST Patent Pending
NPOESS Data Retrieval Via SafetyNet*

Source: S04M13SafetyNetSvalbardVideoSensitiveRestricted.wmv, 3:45 Minutes

* NGST Patent Pending
NPOESS EDR Processing Timeline

Requirement: 95% of data delivered within 28 min.
Capability: Delivering in 21 minutes

Requirement: >77% of data delivered within 15 min.
Capability: Delivering 88%

Earliest Data Delivered < 3 min
Global 95% Data Latency

[Map showing global data latency with latency in minutes indicated by color gradient]
NPOESS Preparatory Project (NPP) Joint IPO-NASA Risk Reduction Demo

• NPP Spacecraft contract awarded to Ball Aerospace – May 2002
• Instrument Risk Reduction
  • Early delivery / instrument-level test / system-level integration and test
    • VIIRS - Vis/IR Imager Radiometer Suite (IPO)
    • CrIS - Cross-track IR Sounder (IPO)
    • ATMS - Advanced Technology Microwave Sounder (NASA)
    • OMPS – Ozone Mapping and Profile Suite (IPO)
  – Provides lessons learned and allows time for any required modifications before NPOESS first launch
• Ground System Risk Reduction
  – Early delivery and test of a subset of NPOESS-like ground system elements
  – Early User Evaluation of NPOESS data products
  – Provides algorithms / instrument verification and opportunities for instrument calibration / validation prior to first NPOESS launch
  – Allows for algorithm modification prior to first NPOESS launch
• Continuity of data for NASA’s EOS Terra/Aqua/Aura missions
Recent NPP Spacecraft Photographs within BATC High Bay
Additional NPOESS Articles On-Line

• There is an NPOESS article in every issue from Jan 2004 through May 2005 (see archives).
  http://www.eomonline.com/currentissues.html

• There are two other sites that might be of interest to students:
  1. The official government web site for NPOESS
     http://www.npoess.noaa.gov
  2. The official NASA web site for NPP
     http://jointmission.gsfc.nasa.gov/
National Polar-orbiting Operational Environmental Satellite System