GSAW 2016

The Earth Observing System (EOS) Ground System: Leveraging an Existing Operational Ground System Infrastructure to Support New Missions

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Terra Launch December 18, 1999

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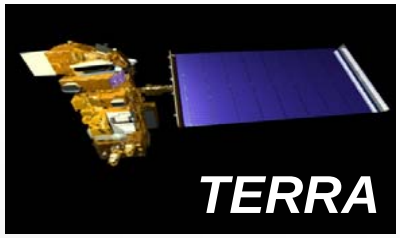
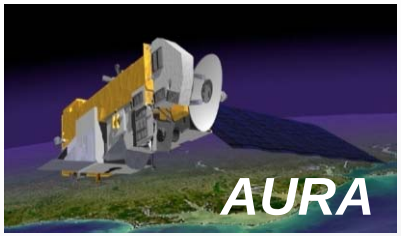
Outline

- High Level Mission and Ground System Overview
- Challenges
- Recent Ground System Enhancements
- Benefits to New Missions
- Conclusions

The Missions





Launch: 12/18/99

- #2 Ranked ES Mission*
- 5 Instruments
- 6-year design life
- Extended to FY20
- Reliability: 2025
- Consumables: 2017/2020

Launch: 05/04/02

- #1 Ranked ES Mission*
- 6 Instruments
- 6-year design life
- Extended to FY20
- Reliability: 2022
- Consumables: 2021

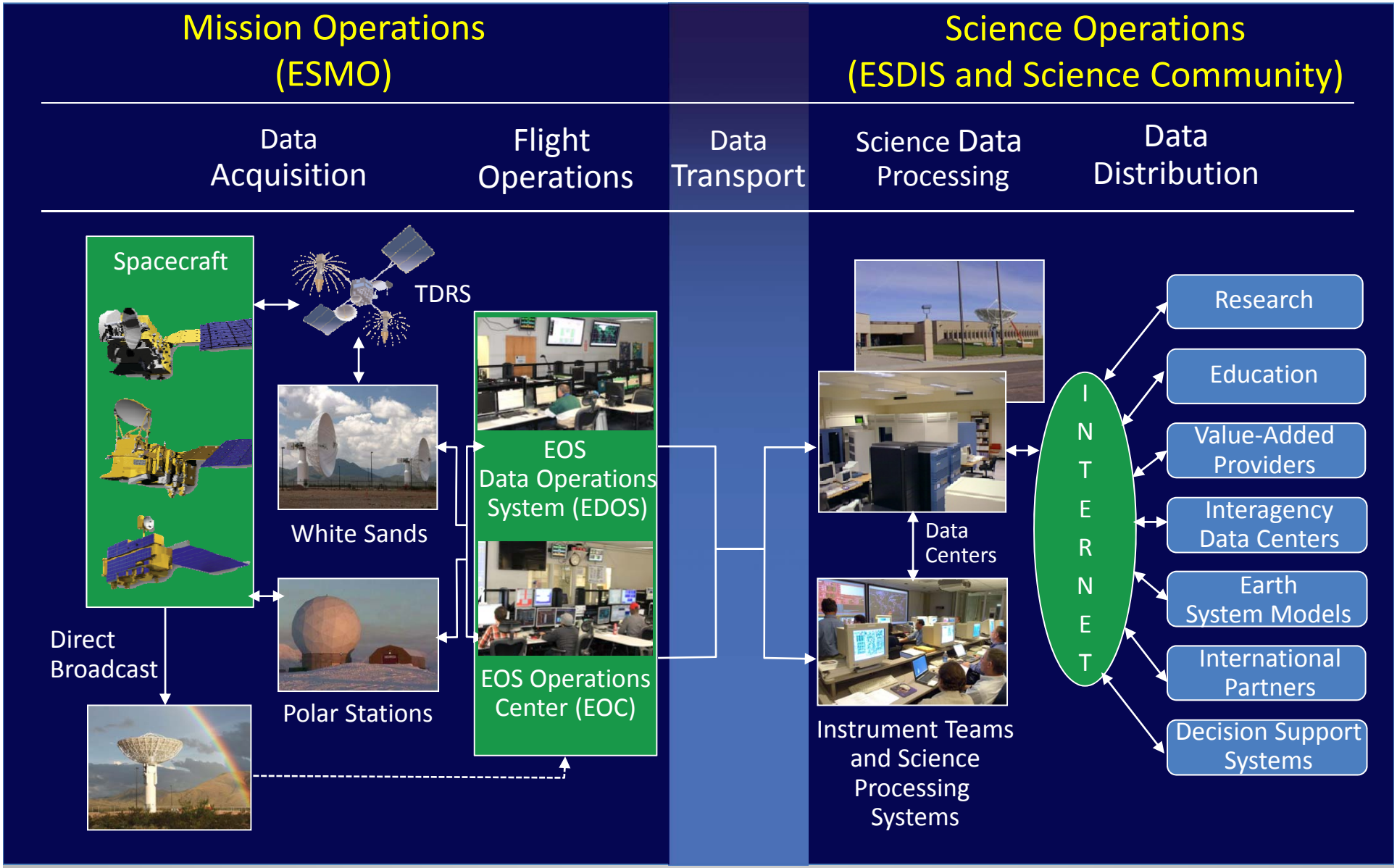
Launch: 07/15/04

- #3 Ranked ES Mission*
- 4 Instruments
- 6-year design life
- Extended to FY20
- Reliability: 2022
- Consumables: 2022+

* Ranking based on 2015 NASA Earth Science Senior Review

Ground system maintenance is critical for the continued operation of these high value and healthy NASA Earth Science Satellites

The Big Picture



The Mission Operations System

Operational since 1999, there are currently three major system components that support all three missions:

Online – Telemetry and Commanding System

- Telemetry Pages and Archiving
- Commanding and Procedure Execution
- Clock Correlation

earthobservatory.nasa.gov

MMS – Mission Management System

- Planning and Scheduling (PAS)
- Command Management System (CMS)
- Data Management System (DMS)

ITPS – Integrated Trending and Plotting System

- Trending and Plotting
- Telemetry archiving for life of mission
- Archive playback
- Data transmission to end users

The Operation Networks

The Mission Operations System operates on one of three redundant local area networks at any given time:

OPS – Operations LAN
SUP – Support LAN

- Redundant LANs located in the same building on GSFC campus
- Failover requires manual intervention, but can be done quickly

BEOC – Backup EOS Operations Center LAN

- Backup LAN located in a different building on GSFC campus
- Regular operational exercises ensure backup capability

With three LANs, one can be taken down for maintenance without losing redundancy, allowing software and hardware updates to be performed

The Challenges

Improve the reliability and flexibility of an aging ground system.

Enable more autonomous ground operations and simplify the integration of new missions.

System Software Updates

The primary EOS software systems (Online, MMS, ITPS) are in *ACTIVE* development. New releases may contain bug fixes, enhancements, or accommodate requirement changes

Updates of operating systems, associated patches, and COTS tools are required to maintain our IT security posture

New Versions Deployed

System	2015	2016 (Planned)
Online	1	2
Online Supplemental COTS Bundles	3	2
MMS	2	1
ITPS	3	2

Frequent deployments maintain staff expertise in change management and updating systems. They also allow new technology and enhancements to be added incrementally with less risk to operations

Automation

An effort was started in 2012 to develop automation capabilities for the EOS ground system.

High-Level Automation Design Concept
Provide a single communications infrastructure
Use R/T event messages to drive monitoring, alerting, & status
Provide a central event archive for anomaly investigations
Use the T&C system for contact automation
Allow for control & extensibility by the FOT
Provide extensibility for new missions and offline tasks
Keep it as simple as possible

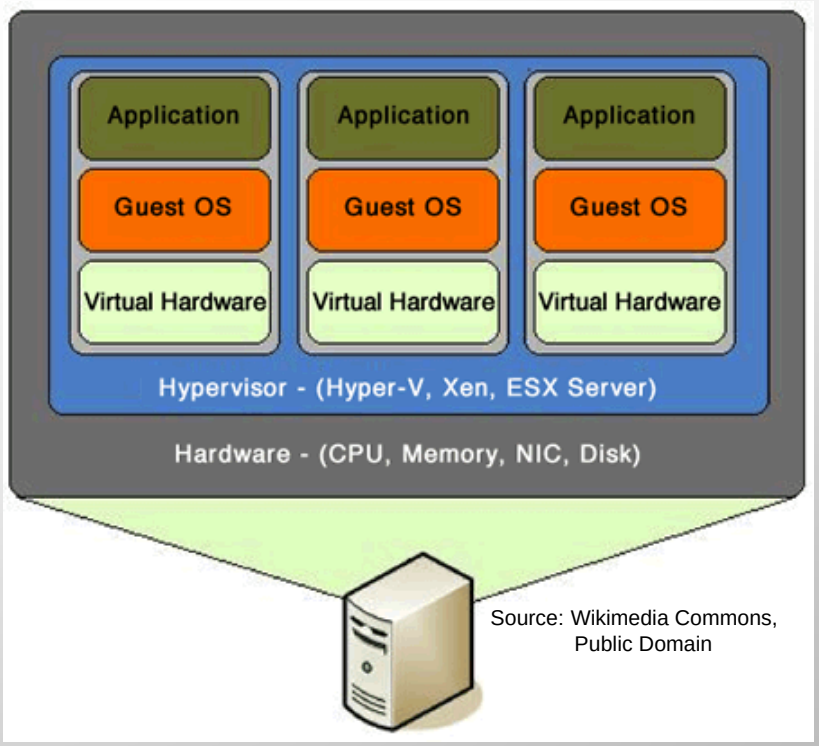
Baseline functions completed. Second phase of automation functions scheduled for operational readiness review in Spring 2016

Leverages off the GMSEC framework developed at GSFC (https://gmsec.gsfc.nasa.gov/)

VM Migration

We are currently in the process of migrating EOS ground system components to a virtual machine infrastructure

- Allows consolidation of hardware which reduces system footprint, power requirements and administration effort
- Ground system functions can be combined and deployed as a set of mission services instead of stand alone subsystems
- New or unproven components can be better isolated from operational systems during development



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Online and ITPS systems are operational in the VM environment

MMS migration is in progress

Network Upgrades

Network infrastructure upgrades are being performed to increase reliability, security and data capacity while reducing data capture and distribution latencies

Highlights from 2015

- Network tech refreshes (replacement of switches, firewalls, console servers) at Wallops Island, White Sands, Svalbard Norway, and three sites in Alaska
- Access switch replacements for all three EOS LANs (OPS/SUP/BEOC)
- Implementation of redundant WDM (wave division multiplex) fiber links between Alaska ground stations

Planned work for 2016

- Upgrades of the EOS backbone network (EBNet) peering design and data links from 10Gbps to 40Gbps
- Tech refresh of the EOS Data and Operations System (EDOS) Level Zero Processing Facility (LZPF) at GSFC

Benefits of EOS GS to a New Mission

Recently a study was performed to analyze the benefits a new Earth science mission would realize from using the existing EOS ground system infrastructure where possible

Several key advantages were identified:

- The ground system architecture is modern, kept current, and operationally proven
- Network architecture is fully deployed - only firewall rules are required to bring new mission systems online
- New systems would fall directly within the Earth Science Mission Operations (ESMO) IT Security Plan boundary. New hosts would be scanned and included in ESMO's host inventory. No need for an independent security plan.

Benefits of EOS GS to a New Mission (continued)

- Configuration and Change management processes are established with Web based tools for change request tracking and approvals
- The VM based architecture allows deployment of new mission GS components in incremental phases that are isolated from existing EOS systems.
- A phased deployment approach combined with a mature operational infrastructure can simplify the transition to operations, lowering operations risk

Conclusions

NASA GSFC has demonstrated that an aggressive continual advancement approach to our flagship earth observing system mission operations center can be performed safely over a period of many years

Regular incremental updates involve less risk than large monolithic changes

- Staff maintain expertise in configuration management, updating, and verifying system operations
- System defects, new requirements, and security vulnerabilities can be prioritized and addressed more quickly
- New technologies can be incorporated in phases with less operational risk

Conclusions (continued)

New technologies now being infused will simplify the addition of new missions into the evolving multi-mission system

New missions can take advantage of established security plans, management processes and the high performance network infrastructure of a modern, operationally proven system

Questions?

Backup

Acronym List

BEOC	Back-up EOS Operations Center
COTS	Commercial Off The Shelf
CMS	Command Management System
DAAC	Distributed Active Archive Center
DAM	Debris Avoidance Maneuver
DB	Direct Broadcast
DMS	Data Management System
EBNet	EOS Backbone Network
EDOS	EOS Data and Operations System
EMOS	EOS Mission Operation System
EOC	EOS Operations Center
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
ESMO	Earth Science Mission Operations
FOT	Flight Operations Team
GMSEC	GSFC Mission Services Evolution Center
GS	Ground System
GSAW	Ground System Architectures Workshop
GSFC	Goddard Space Flight Center
H&S	Health and Safety
IT	Information Technology
ITPS	Integrated Trending and Plotting System
LAN	Local Area Network
LEO	Low Earth Orbit
LZPS	Level Zero Processing Facility
MMS	Mission Management System
NEN	Near Earth Network
OPS	Operations
PAS	Planning and Scheduling
R/T	Real-Time
SIPS	Science Investigator-led Processing Systems
SUP	Support
T&C	Telemetry and Commanding
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
VM	Virtual Machine
WDM	Wave Division Multiplexing
WSC	White Sands Complex

The Science Data System

The EOS Data and Operations System (EDOS) is a high-rate, multi-mission science data system that supports seven operational missions as well as the upcoming ICESat-2

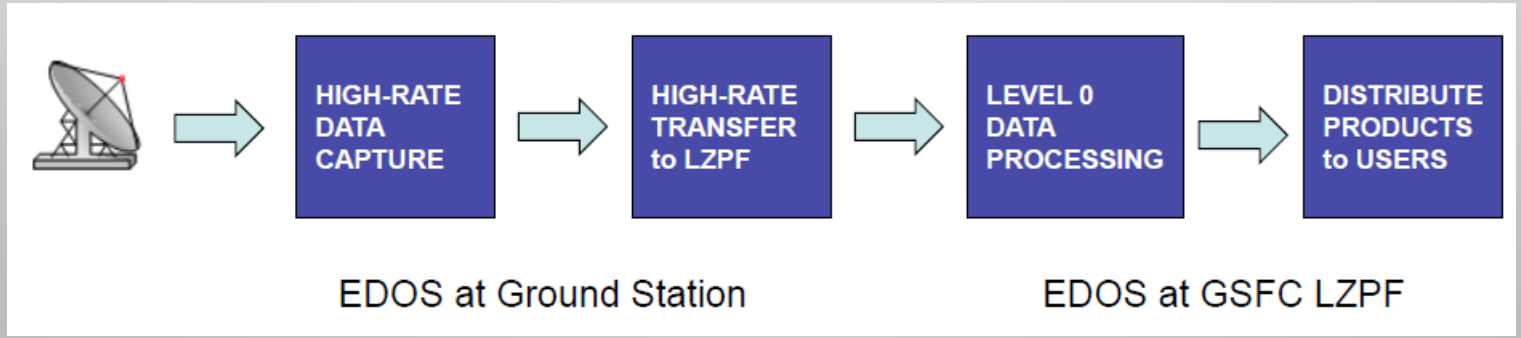
Autonomously captures science data at remote ground stations

- EDOS capture systems are located at 6 sites serving 16 antennas
- Front-end processing includes demodulation, frame synchronization, and decoding, as needed

Performs initial level zero science data processing

Transfers science data to GSFC over NASA's closed high-rate network or high-rate open (Internet) networks with increased bandwidth, where available

Currently delivers more than 1/2 Terabyte of level-zero products worldwide (20 external customers) in a variety of formats and protocols on a daily basis



Benefits of EDOS to a New Mission

Benefits of using the existing EDOS infrastructure for science data capture and front-end processing:

- 24x7 operations support monitoring all station contacts and product deliveries for all missions and customers
- Additional EDOS capture systems can be easily added at existing (or new) ground stations worldwide as part of a modular, scalable architecture
- No schedule interface is required due to data-driven design assuring 24x7 data capture for any EDOS mission
- Existing integrated high-rate networks provide reduced product latencies
- Proven interface to EOSDIS Distributed Active Archive Centers for product distribution
- Additional spare capacity exists in existing system. More can be added!
- Reduced project risk by using existing EDOS infrastructure at a fraction of the cost of developing a new system

Data Processing Levels

EOSDIS data products are processed at various levels ranging from Level 0 to Level 4. Level 0 products are raw data at full instrument resolution. At higher levels, the data are converted into more useful parameters and formats. All EOS instruments must have Level 1 products. Most have products at Levels 2 and 3, and many have products at Level 4

Data Level	Description
Level 0	Reconstructed, unprocessed instrument and payload data at full resolution, with any and all communications artifacts (e.g., synchronization frames, communications headers, duplicate data) removed. (In most cases, the EOS Data and Operations System (EDOS) provides these data to the data centers as production data sets for processing by the Science Data Processing Segment (SDPS) or by a SIPS to produce higher-level products.)
Level 1A	Reconstructed, unprocessed instrument data at full resolution, time-referenced, and annotated with ancillary information, including radiometric and geometric calibration coefficients and georeferencing parameters (e.g., platform ephemeris) computed and appended but not applied to Level 0 data.
Level 1B	Level 1A data that have been processed to sensor units (not all instruments have Level 1B source data).
Level 2	Derived geophysical variables at the same resolution and location as Level 1 source data.
Level 3	Variables mapped on uniform space-time grid scales, usually with some completeness and consistency.
Level 4	Model output or results from analyses of lower-level data (e.g., variables derived from multiple measurements).