PART 1. BASELINE MISSION

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1. OVERVIEW

The Earth Observing-1 (EO-1) Mission was developed as part of the NASA New Millennium Program (NMP). The NMP was established in 1994 to respond to the challenge of the NASA Administrator to develop faster, better, and cheaper missions. The NMP was charged to develop and flight-validate revolutionary technologies; reduce development risks and life cycle costs of future science missions; enable highly capable and autonomous space systems; and, promote nationwide technology teaming and coordination. In addition, the EO-1 Mission was to be responsive to the Land Remote Sensing Policy Act of 1992 (Public Law 102-55) wherein NASA was charged to ensure Landsat data continuity through the use of advanced technology. Consequently, EO-1 was designed to flight-validate breakthrough technologies applicable to Landsat follow-on missions. More specifically, EO-1 developed a multispectral imaging capability that addressed the traditional Landsat user community; hyperspectral imaging capability with backward compatibility that addressed the Landsat research-oriented community; calibration test bed to improve absolute radiometric accuracy; and atmospheric correction to compensate for intervening atmosphere effects. Noteworthy is the fact that the EO-1 multispectral land imaging instrument, containing advanced technology elements, has a significant improvement in performance over the Landsat-7 ETM+ instrument and at significantly lower cost.

The Jet Propulsion Laboratory (JPL) currently manages the overall NMP for the agency. The process of formulating an NMP mission, outlined above, was established by them. Certain Earth Observing missions have been assigned to GSFC as lead center. EO-1 was managed at GSFC, making it the EO-1 performing center. Overall program management was provided by the NMP/EO Program Office at the Goddard Space Flight Center (GSFC). Dr. Bryant Cramer is the EO-1 Program Manager, Mr. Dale Schulz was the EO-1 Mission Manager, and Dr. Stephen Ungar is the EO-1 Mission Scientist.

The EO-1 Mission was approved for flight on March 22, 1996 by the Earth Science Enterprise at NASA HQ and was launched on a Delta II rocket from Vandenberg Air Force Base on November 21, 2000. EO-1 was launched into a polar orbit with an equatorial crossing time of 10:03 a.m. (descending node), an altitude of 705 km, an inclination of 98.2˚, and an orbital period of 98 minutes. The mission had a design life of 18 months and a nominal life of 12 months.

Baseline operations consisted of 5-7 ground station passes per day transmitting both S-and X-band data to stations in Norway and Alaska. Science data was transmitted by X-band at up to 120 Gbits per day which corresponds typically to 5-7 Data Collection Events (DCEs) each day at 105 Mb/s rate. Housekeeping data, as well as backup science data, is transmitted by S-band at up to 2 Mb/s. This downlink results in up to 200 Mbits of housekeeping data per day and up to 5 Gbits per day of backup science data.

Following completion of the EO-1 Baseline Mission in November 2001, NASA Headquarters approved extending the mission life of EO-1 with an agreement reached between NASA and the U.S. Geological Survey (USGS). The USGS EROS Data Center (EDC) has assumed responsibility for all customer interface services related to the acquisition, archival, and distribution of EO-1 image data. EO-1 archives of ALI and Hyperion data can now be directly queried and ordered with the USGS Earth Explorer interface (http://earthexplorer.usgs.gov). Data Acquisition Requests (DARs) for tasking the spacecraft can also be made through the USGS, should archive data not be available for your area of interest. Further information can be obtained by viewing the USGS website at http://eo1.usgs.gov.

2. OBJECTIVES

Technologies within the NMP that are selected to fly on a certain missions are divided into three categories depending on their assigned role on a given validation flight. Category 1 technologies are considered crucial to the flight. Should one encounter difficulty, the flight will be delayed and/or restructured to accommodate it. Category II technologies proceed in parallel with an alternative approach based on a conventional technology. If the new technology encounters difficulty, then it is removed from the flight and the flight proceeds with the shadowing conventional technology. These technologies often represent an essential function in one of the instrument(s) or on the spacecraft. Category III technologies are flight opportunities that are designed so that their failure to materialize does not critically impact the Category I or II technologies on the mission. In this case, should they encounter difficulty, they will simply be removed from the flight. These technologies represent non-critical payloads. A given NMP flight is a mixture of all three categories and is determined by the flight validation priorities, the nature of the individual technologies, and the aggregate risk acceptable to the NMP flight.

The objective of the EO-1 Mission, as established in NASA HQ's Level 1 Requirements, was to validate the following breakthrough technologies:

- Multispectral Imaging Capability: Category I
- Wide Field, High Resolution, Reflective Optics: Category I
- Silicon Carbide Optics: Category I
- Hyperspectral Imaging Capability: Category III
- Atmospheric Corrector: Category III
- X-Band Phased Array Antenna: Category II
- Wideband Advanced Recorder and Processor: Category II
- Enhanced Formation Flying: Category III
- Lightweight Flexible Solar Array: Category III
- Carbon-Carbon Radiator: Category III
- Pulsed Plasma Thruster: Category III
- LA-II Thermal Coating: Category III

These breakthrough technologies are shown pictorially in Figure 1 and their locations on the EO-1 spacecraft bus are depicted in Figure 2. Two photographic views of the assembled EO-1 observatory are presented in Figure 3.

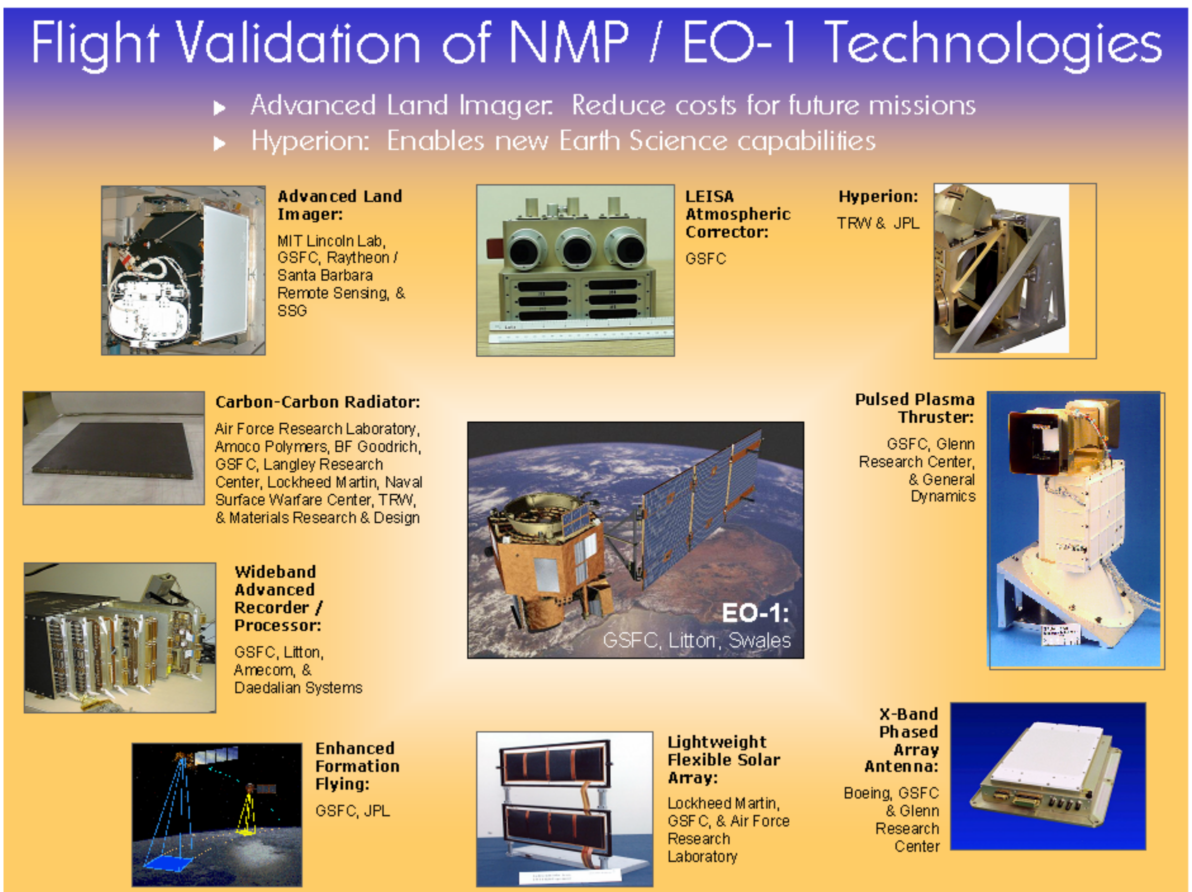


Figure 1 – Flight Validation of NMP / EO-1 Technologies

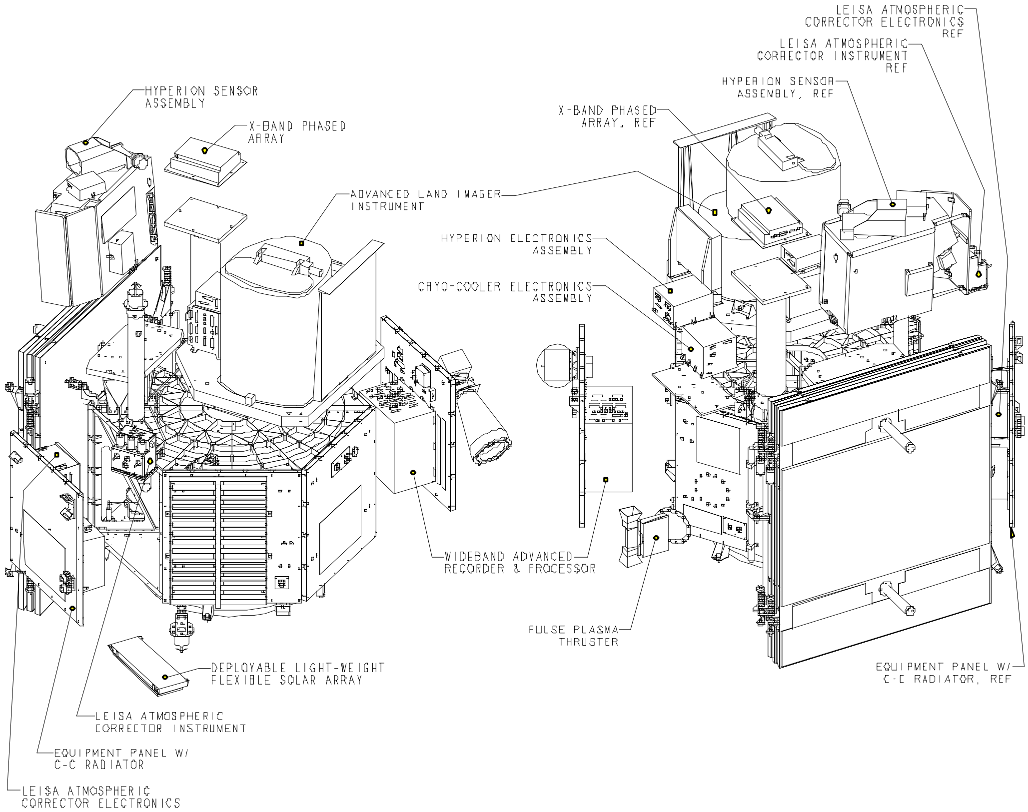


Figure 2 – EO-1 Technology Locations

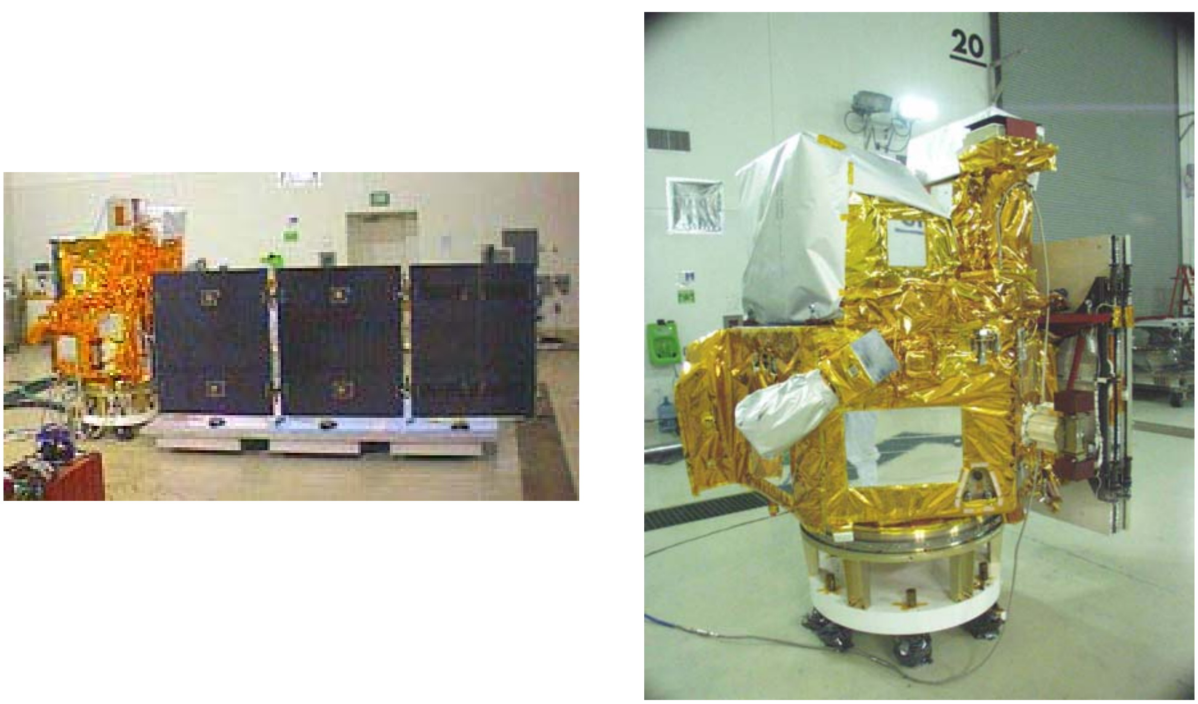


Figure 3 – EO-1 Integrated Spacecraft

In addition, under a NASA Research Announcement (NRA-99-OES-01) jointly issued by NASA and the U.S. Geological Survey (USGS), an additional objective was established. The stated objective was to evaluate the ability of the instruments to produce images suitable for performing defined science validation investigations. As a result, 30 principal investigators were selected to form a Science Validation Team (SVT).

3. TOP LEVEL REQUIREMENTS

The EO-1 Mission was to validate a number of technologies that were to provide the basis for Landsat follow-on instruments with increased performance, significantly lower mass and power, and at substantially lower cost. More specifically, EO-1's Advanced Land Imager (ALI) was to validate multispectral land imaging capabilities based on a novel hybridized Sensor Chip Assembly (SCA) used in a modular pushbroom configuration. The Hyperion instrument was to validate hyperspectral land imaging capabilities. A third instrument, the Atmospheric Corrector (AC), was to validate the ability to provide correction for water vapor extinction. These technologies were to be validated in coordination with the Landsat-7 mission. In addition to the technologies incorporated into the ALI, several other technologies of significant importance to future remote sensing missions were to be validated on the EO-1 flight.

The EO-1 Mission flight was to validate the following technologies within the Earth Science Enterprise (ESE) allocated budget including one year of operations with a launch readiness date during the 3rd quarter CY00. The EO-1 spacecraft was part of a combined launch with the SAC-C spacecraft on a Delta 7320 launch vehicle from the Western Test Range.

The first three technologies listed below comprise the Advanced Land Imager (ALI).

3.1 "Pushbroom" Multispectral Imaging Capability: Category I

This technology was to demonstrate an affordable, straightforward approach to a fully calibrated multispectral Landsat follow-on instrument of substantially lower mass and cost. This technology is directly responsive to the language of the Land Remote Sensing Policy Act wherein NASA is charged to ensure Landsat data continuity through the use of advanced technology.

Specific requirements were as follows:

- Use nine discrete multispectral bands, each with 30 meters ground resolution, spanning a spectral range of 0.4 through 2.5 micrometers, and a single panchromatic band of 10 meters resolution, spanning the spectral range of 0.5 through 0.7 micrometers, to gather Landsat-type images across a 37 kilometer contiguous swath width from an orbit covering the same ground track as Landsat-7.

- Evaluate a lunar and solar calibration capability as a step toward ultimately achieving 5% absolute radiometric accuracy in future science missions.

- Gather a representative sample of multispectral terrain images that capture the seasonal variations encompassing one growing season (March through October) in the Northern Hemisphere.

- Evaluate the capabilities of the ALI for future Landsat and other ESE missions by performing up to 200 paired-scene comparisons with Landsat for representative spectral reflectance of known targets within the cross track pointing capability of the spacecraft (+/- 20 degrees).

- Provide ground-to-ground formation flying with Landsat-7 of sufficient precision to support the collection of data for the above paired-scene comparisons. The EO-1 ground track should remain within 3 km of the Landsat-7 ground track in the cross track direction and with a one-minute nodal separation.

- Operate the entire focal plane at a nominal 220 K to demonstrate the high temperature capability of the near and short wavelength infrared detectors.

3.2 Wide Field, High Resolution, Reflective Optics: Category I

This technology was to demonstrate the basis for a Landsat-equivalent swath width (185 km) and resolution (30 m) in a "pushbroom" mode. It was to determine how well the optical performance of the ALI matched the above stated requirements for the Pushbroom Multispectral Imaging Capability.

3.3 Silicon Carbide Optics: Category I

This technology was to demonstrate the basis for reflective optical systems that are lightweight and stable over a wide range of operating temperatures. The EO-1 silicon carbide primary mirror represents the largest such mirror produced to date. It was to determine how well the silicon carbide optics provides the necessary optical performance to achieve the above stated requirements for the Wide Field, High Resolution, Reflective Optics.

3.4 Hyperspectral Imaging Capability (Hyperion): Category III

This technology was to demonstrate the basis for future grating-based hyperspectral imaging systems and was to demonstrate the potential usefulness of hyperspectral imaging in scientific research and in commercial applications of remote sensing from space. Hyperspectral imaging provides considerably greater spectral detail and is anticipated to open new vistas in land remote sensing. This technology validation was to evaluate the synthesis of Landsat-type images from hyperspectral imaging data by comparing them with actual Landsat-7 and ALI images.

Specific requirements were as follows:

- Use the Hyperion capability to gather spectral images of 30 meter ground sample distance and 10 nm spectral resolution spanning a spectral range of 0.4 to 2.5 micrometers across a 7.5 km swath width overlaying a portion of the ALI swath from an orbit covering the same ground track as Landsat-7.

- Collect at least 1,000 "Hypercubes" for demonstrating the potential usefulness of hyperspectral imaging for both scientific research and commercial applications. A Hypercube is a dataset that is 19.2 km long, 7.5 km wide and containing 220 spectral channels.

- Use hyperspectral imaging data to synthesize Landsat-type images to be used in comparison with images produced by Landsat-7 (ETM+) and ALI.

- Periodically evaluate lunar and solar calibration capabilities that can ultimately improve absolute radiometric accuracy in future science missions.

- Gather a representative sample of hyperspectral terrain images that capture the seasonal variations encompassing one growing season (March through October) in the Northern Hemisphere.

3.5 LEISA Atmospheric Corrector (AC): Category III

This wedge filter-based hyperspectral technology was to demonstrate the basis for being able to enhance the value of land imaging data by providing correction of atmospheric extinction due to water vapor and cirrus clouds.

Specific requirement were as follows:

- Assess use of LEISA Atmospheric Corrector data to determine atmospheric water vapor, aerosols, and clouds;

- Assess use of LEISA Atmospheric Corrector data to correct paired Landsat-7 and ALI images for the effect of atmospheric extinction;

- Assess the impact of using a 250 m-pixel size by comparing the resultant corrections obtained from corresponding Hyperion data.

Table **1** shows a comparison of the salient functional parameters for the Landsat-7 ETM+ and the three EO-1 instruments. Figures 4 and Figure 5 illustrate the EO-1 and Landsat-7 formation flying parameters and comparative swath coverage for the various instruments.

Parameters	Landsat-7	EO-1	EO-1	
	ETM+	ALI Multispectral	Hyperion	AC
Spectral Range	0.4 – 2.4 µm*	0.4 – 2.4 µm	0.4 – 2.5 µm	0.9 – 1.6 µm
Spatial Resolution	30 m	30 m	30 m	30 m
Swath Width	185 km	37 km	7.5 km	185 km
Spectral Resolution	Variable	Variable	10 nm	4 – 9 nm **
Spectral Coverage	Discrete	Discrete	Continuous	Continuous
Pan Band Resolution	15 m	10 m	N/A	N/A
Total Number of Bands	7	10	220	256

* Excludes thermal channel ** 35/55 cm^{-1} constant resolution

Table 1 – Instrument Comparison of Landsat-7 ETM+ and EO-1

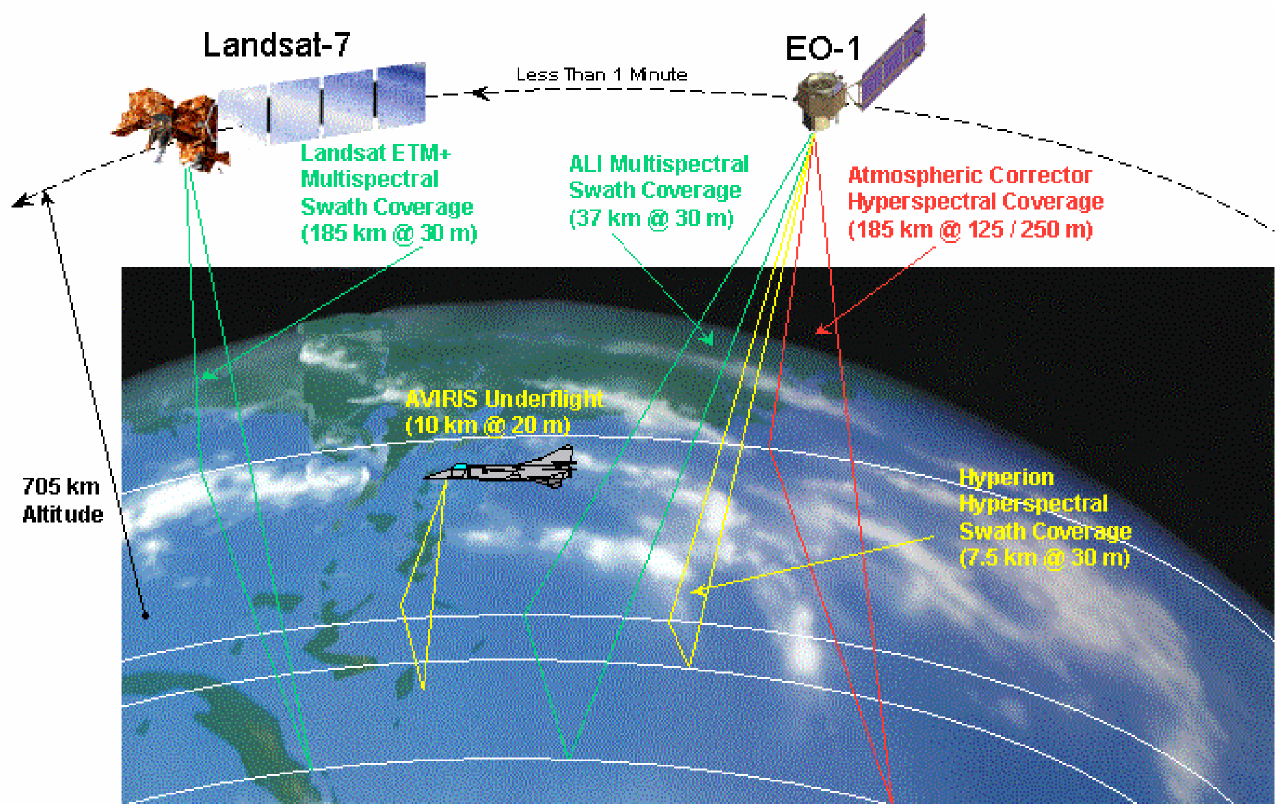


Figure 4 – EO-1 and Landsat-7 Formation Flying Parameters

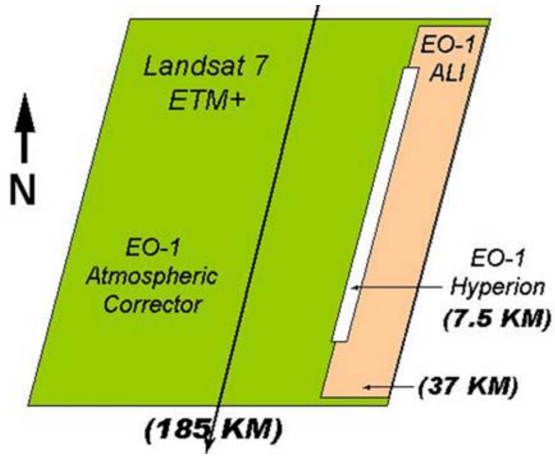


Figure 5 – EO-1 and Landsat-7 Comparative Swath Coverage

3.6 X-Band Phased Array Antenna (XPAA): Category II

This technology was to demonstrate the needed performance of a lightweight, electronically steerable antenna for X-band downlink transmissions. It was to provide science data downlink in excess of 100 Mbs utilizing CCDS standards, establish link error performance, and establish the antenna pattern scan performance periodically throughout the first year on orbit.

3.7 Wideband Advanced Recorder and Processor (WARP): Category II

This technology was to demonstrate the ability of a high data rate solid state recorder to capture the high rate range of data from the Advanced Land Imager, Atmospheric Corrector, and Hyperion instruments. The WARP was to have a high rate capability (up to 900 Mbps), high storage density (48 Gbit), low weight (less than 22.0 kg) with X-band modulation capability. It was also to include a Mongoose V processor that could perform on-orbit data collection, compression, and processing of land image scenes.

3.8 Enhanced Formation Flying (EFF): Category III

This technology was to demonstrate the basis for flying over the same ground track of another earth-observing spacecraft at a fixed separation in time which was autonomously maintained with minimal ground-based involvement. It was to demonstrate the capability to fly within 3 km (cross track direction) over the same ground track as Landsat-7 at a nominal one-minute nodal separation.

3.9 Lightweight Flexible Solar Array (LFSA): Category III

This technology was to demonstrate the basis for future lightweight solar panels. The LFSA was to demonstrate a controlled deployment using Shaped Memory Alloy hinges and to demonstrate a solar array capability of greater than 100 W/kg throughout the first year on orbit.

3.10 Pulsed Plasma Thruster (PPT): Category III

This technology was to demonstrate the basis for a low mass, low cost, and highly reliable propulsion system to be utilized as an attitude control element in place of the traditional higher cost, heavier, and less reliable reaction wheels. It was to demonstrate a control capability that included pointing accuracy, response characteristics, and stability. Also, it was to qualitatively confirm that the thruster plume was benign to the optical surfaces of the ALI, Hyperion, and Atmospheric Corrector as assessed in images collected both before and after activation of the PPT.

3.11 Carbon-Carbon Radiator (CCR): Category III

This technology was to demonstrate the basis for radiators that are considerably lighter and possess greater thermal conductivity than their contemporary aluminum counterparts. It was to periodically confirm the anticipated thermal performance throughout the first year on orbit and to qualitatively assess that there had been no impact of contamination on the optics of the ALI, Hyperion, and Atmospheric Corrector instruments by examining successive images throughout operations.

3.12 LA-II Thermal Coating: Category III

This technology was to demonstrate the characteristics of a low absorptance inorganic white paint for thermal control purposes that would allow spacecraft radiators to run cooler when exposed to an UV environment and thereby provide improved thermal control performance. One calorimeter disc was to be coated with the LA-II paint and another with a standard Z93P white paint to be used for baseline comparison. It was required to monitor the temperature of both calorimeter discs to assess the comparative performance of the LA-II coating.

3.13 Mission Science Validation

To meet the stated science validation objectives, the following three requirements were levied on the SVT.

- Evaluate the selected EO-1 technologies with respect to their ability to meet the needs for future Landsat-class observatories at substantially reduced cost and mass and with enhanced quality. This requirement was in direct response to the Land Remote Sensing Policy Act of 1992 referred to earlier.

- Evaluate the performance of space-based imaging spectrometers for potential future NASA and USGS scientific, applied, and commercial uses of hyperspectral data.

- Evaluate the advantageous use of inter-satellite, solar, and lunar calibration techniques and atmospheric correction.

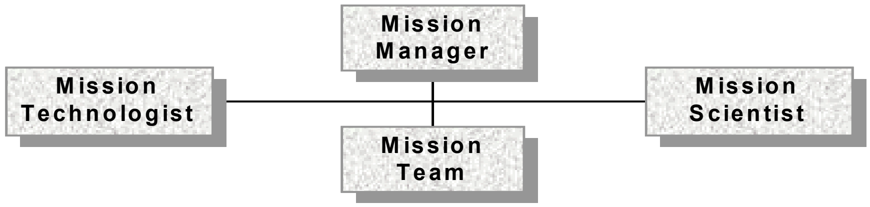
By satisfying the above requirements, all of the technologies have been successfully validated and validation summaries and full reports are presented in Part 3. The SVT investigators have completed their science validation studies and the results are presented in Part 4.

4. IMPLEMENTATION PLAN

The following sections describe the implementation plans for the NMP EO-1 Mission. These plans address all of the processes and practices of a conventional project on a scale commensurate with the NMP EO-1 Mission's smaller resources and shorter development-to-launch schedule. More specifically, the Mission Implementation Plan recognized the need to establish a Mission Team in the early definition phase; recognized that NMP missions are NOT science missions and cannot be treated as such – they are inherently more risky; and applied the following "keys to success":

- Resilient "Category" Architecture;
- Comprehensive, aggressive risk management;
- Adequate reserves in schedule and budget;
- Critical role of Mission Technologist;
- Strong system engineering;

- Focused mission management approach as shown below:

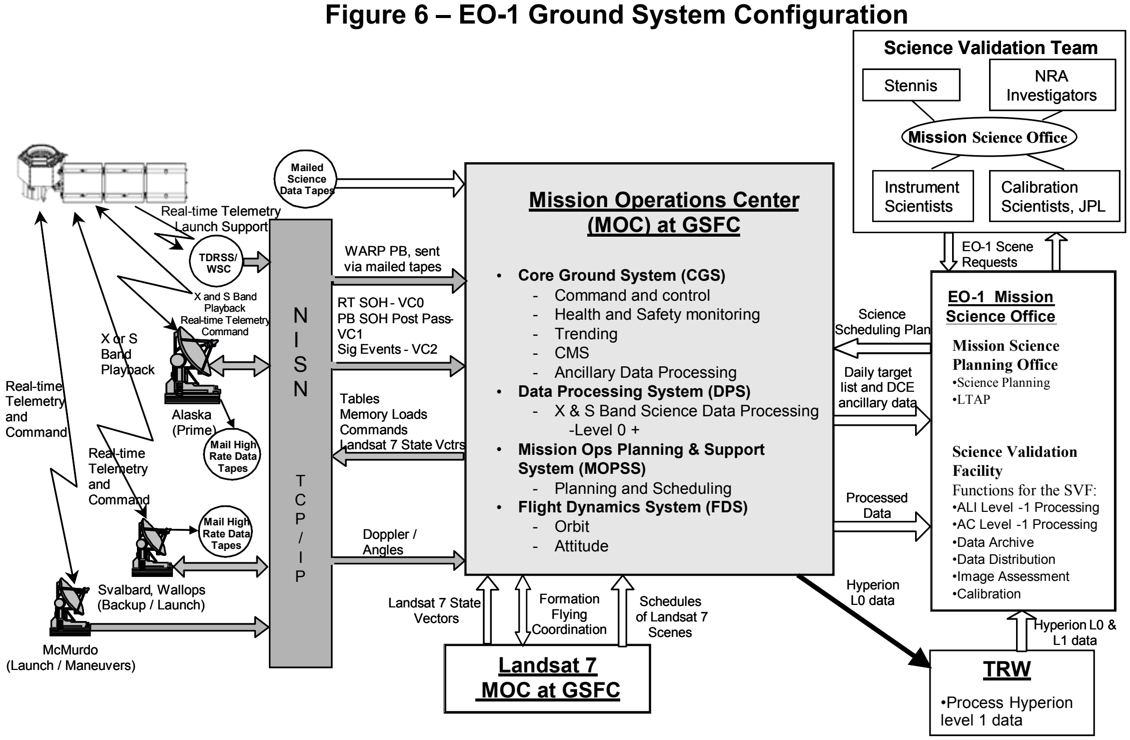


4.1 Mission Operations

The Operations Plan is documented in the *EO-1 Mission Procedures Document (MPD)*. It is a working document for the Flight Operations Team (FOT) to conduct the mission. It covers how both the space and ground segments operate and how they interact to achieve the EO-1 Mission objectives. The MPD consists of two volumes. Volume One is the Operations Concept, and Volume Two is a comprehensive gathering of all operations to be performed on the ground and the spacecraft.

The Pre-Launch Testing Phase and the Launch And Early Orbit Phase are covered in the *EO-1 Ground System Test Plan* and Volume Two of the MPD. Figure 6 illustrate the EO-1 Ground System Configuration.

Figure 6 – EO-1 Ground System Configuration



4.2 Safety Plan

The Safety Plan presents guidelines on how to eliminate hazards and reduce the associated risk to a level appropriate for the EO-1 Mission. The spacecraft vendor, Swales Aerospace (SAI), was responsible for the integration of the spacecraft, for the performance of the integrated safety assessment, and for the development of all safety documentation required at the launch site. SAI tailored the *Eastern/Western Range Safety Requirement (EWR) 127-1* to document the applicable EO-1 Mission-specific safety requirements. All safety requirements were satisfied/closed through the development and approval of an EO-1 *Missile System Pre-launch Safety Package (MSPSP).*

4.3 Acquisition Plan

Innovative acquisition procedures were used in order to meet the challenge of a cost-constrained mission. These activities were consistent with sound business practices and governing policies. The most significant procurement activities applicable to the EO-1 Mission are as follows:

- Spacecraft;
- ALI Instrument;
- Hyperion Instrument;
- Atmospheric Corrector Instrument;
- Spacecraft Technologies;
- Ground System.

The spacecraft development was a joint effort between SAI and Litton Amecon. SAI was previously selected in February 1994 through an open competition under Request for Proposal (RFP) 5-33386-229 to provide engineering system support to GSFC. The work for EO-1 was a performance-based fixed price task order under the resultant contract (NAS5-32650). The Wideband Advanced Recorder/Processor (WARP), the Global Positioning System (GPS), and the S-band transponder were government-furnished to SAI.

The Advanced Land Imager (ALI) instrument was developed by MIT/Lincoln Laboratory as Program 757 under Air Force Contract No. F19628-95-C-0002. NASA funding was transferred by a New Technology Interdepartmental Transfer of Funds Agreement, NASA-Defense Purchase Request (NDPR) S-27342F. MIT/LL was selected to provide the instrument based on its membership on the New Millennium Program Instrument Technologies and Architecture Integrated Product Development Team. Team members were solicited through performance-based Letters of Solicitation and participated in a formal proposal process. Raytheon/Santa Barbara Remote Sensing and SSG Inc. were major subcontractors to MIT/LL. Santa Barbara Remote Sensing built the focal plane system and SSG Inc. built the telescope subsystem. Instrument implementation, through on-orbit checkout, continued under the NDPR.

The Hyperion instrument was added to the EO-1 Mission after implementation had begun. It was confirmed by NASA HQ Code Y in December 1998. The initial study effort was contracted with TRW under an existing JPL contract. It covered the definition effort through a Critical Design Review. In order to minimize the impact to the EO-1 Mission by adding the Hyperion late, a letter contract was issued to TRW by GSFC that was definitized in November 1998 for the implementation of the Hyperion instrument. It was a Cost-Plus-Incentive Fee contract, NASS-918161. SSG Inc. built the telescope under a fixed price subcontract.

The Atmospheric Corrector instrument was an in-house procurement.

Flight validation of promising spacecraft technologies is an important part of the NMP's effort to reduce costs and to enhance the performance of future science missions. Technologies were initially identified by an Architecture Development Team working with the Instrument Technologies and Architecture Integrated Product Development Team. The technologies assigned to fly on the EO-1 Mission were selected based upon the NMP's Technical Selection Plan, *JPL-D-13361*. Candidate technologies were identified in May 1996 with final selection in July 1996. Selections were made by the NMPO at GSFC with concurrence from NASA HQ's Code Y. Fixed price contracts were used whenever practical. The effort to integrate the technologies onto the spacecraft was included in the implementation task with SAI.

The ground system development was an "in-house" effort. There was no prime contractor. The Flight Operations Team was provided by the Agencywide Consolidated Space Operations Contract (CSOC) under a Space Operations Directive Agreement (SODA). The hardware and software system in the Mission Operation Center (MOC) was based on the Advanced Spacecraft Integration and System Test (ASIST) architecture being developed at GSFC by the Applied Engineering and Technology Directorate (AETD).

4.4 Risk Management

The Risk Management process followed by the EO-1 project consisted of the following:

- Focused on early identification, mitigation, and timely decisions;
- Emphasized action rather than process;
- Communicated with minimal paperwork;
- Maintained integrated development nature of the EO-1 spacecraft and its associated new technologies;
- Made comprehensive review of all risks as an essential element of the Mission's milestones.

The risk management process consisted of risk identification, risk categorization, risk mitigation planning, and risk analysis. The focus was on technical, programmatic, supportability, cost, and schedule categories. Integrated risk assessments supported management decisions throughout the lifetime of the mission and were communicated to senior NASA management as appropriate.

Early in the mission planning stage, changes were made in Operations that resulted in a cost-effective mitigation of risk. Section 5 contains a discussion of this activity.

4.5 Resources Management

The intent of the EO-1 resources management was to establish and control cost, staffing, and facility requirements. The mission was cost constrained. All of the EO-1 Team, whether in-house at GSFC or outside contractors, was expected to work with the Mission to control costs and accomplish the schedule. Design-to-Cost allocations were established for all of the major cost elements consistent with the budget. Cost reserves were limited so the ability to overcome unanticipated problems was restricted. To be ready to implement cost reductions in the event of problems, appropriate technical elements were identified up-front and made ready to be descoped.

4.6 Funding Requirements

The hardware implementing contractors submitted monthly reports that included technical progress, problems, proposed problem resolution, cost, schedule status, and manpower. The EO-1 Mission made every effort to simplify government/contractor interfaces and reduce duplication of effort. Reporting was at a level appropriate to the complexity of the effort and compatible with the contactor's established accounting and reporting system. Given the modest cost of the hardware implementation efforts for the spacecraft and the instruments and the capabilities of the contractors, an earned value reporting was not used.

4.7 Schedule Management

The EO-1 Mission was responsible for the end-to-end schedule integration of the elements that comprised the EO-1 Mission. EO-1 major mission elements include the spacecraft, ALI instrument, Hyperion instrument, Atmospheric Corrector instrument, NMP technology components, science data processing, and the ground system. The Mission established a set of top-level configuration controlled milestones for top-down planning purposes. It distributed these milestones and the requirements for the schedule baseline, monthly status, and reporting requirements to the participating partners. Automated scheduling tools were used to develop, integrate, status, and analyze master, intermediate, and detailed level schedules. Mission partners developed detailed baseline schedules for Mission review and concurrence. From this information, the Mission developed the Master Schedule, built intermediate logic networks, and identified the critical path to launch. A top-level schedule analysis including the critical path status was reported on a monthly basis to the NMPO, Goddard Program Management Council (GPMC), and NASA HQ as requested.

4.8 Configuration Management (CM)

The EO-1 Mission implemented a CM system. The Mission CM Lead was the EO-1 Mission Systems Engineer who had signature authority with the concurrence of the Mission Manager. The Mission Systems Engineer chaired the Configuration Control Board (CCB), which consisted of the Observatory Manager, the Instruments Managers, the Mission Operations Director, the Mission Assurance Manager, the Launch Campaign Manager, and the NMP Program Business Manager.

Each mission element maintained its own documentation. For example, the Hyperion instrument provider maintained its drawings, internal interface documentation, internal mass and power allocations, etc.

Changes that did not affect cost, schedule, and top-level requirements did not require concurrence by the CCB. For changes affecting cost, schedule, etc., the Mission Systems Engineer consulted with the board members, but had decision authority with the concurrence of the Mission Manager.

Overall configuration management information and documents are contained in the Appendix.

4.9 Logistics

The EO-1 Mission coordinated with the NASA/GSFC Logistics Management Division (Code 230) regarding Integrated Logistics Support (ILS) planning and engineering through the Implementation Phase of the Mission. Assistance was provided in all elements of ILS, including parts and materials, support and test equipment, and transportation. The Mission Support Manager was designated as the Mission focal point for ILS. All necessary actions, resources, and methods were implemented to ensure the proper and safe movement of mission systems, material, flight hardware, documentation, and support equipment. Transportation engineering support was provided to the spacecraft contractor as required for early identification of transportation requirements for flight hardware and GSE.

4.10 Technology Infusion Plan

By virtue of how the NMP is organized, there has been significant opportunity for technology infusion through participation of the six Integrated Product Development Teams (IPDTs). **Table 2** lists the organizations involved in the EO-1 technologies. An IPDT lead for each technology was selected to provide a technology validation plan to the Project. Each validation plan has two parts (technical and science). Once the spacecraft was in orbit, each IPDT lead was responsible for implementing the objectives of the validation plan. After flight validation, the Mission Technologist and Technology Provider were to prepare Technology Transfer Documentation based on:

- Basic design features and planned performance;
- Ground-based calibration and characterization;
- On-orbit technical and science validation;
- Operational experience
- Likely applications

Candidate Technology	Organizations
Multispectral Imaging Capability	MIT/LL & Raytheon/SBRS
Wide Field, High Resolution, and Reflective Optics	MIT/LL & SSG
Silicon Carbide Optics	SSG
Hyperspectral Imaging Capability	TRW & JPL
Atmospheric Corrector Capability	GSFC
X-Band Phased Array Antenna	Boeing, GSFC, & GRC
Wideband Advanced Recorder/Processor	GSFC, Litton Amecon, & Daedalian Systems
Enhanced Formation Flying	GSFC and JPL
Lightweight Flexible Solar Array	Lockheed-Martin, GSFC, & AFRL
Carbon-Carbon Radiator	CSRC
Pulsed Plasma Thruster	General Dynamics, GSFC, & GRC
LA-II Thermal Coating	AZ Technology

Table 2 – Technology Organizations

IPDTs, NMP workshops, technology fairs, etc. are to be used to disseminate the Technology Transfer documentation. The NMP is to work closely with the Earth Science Technology Office to facilitate technology infusion into future science missions. The same IPDT lead was to oversee the analysis of the data and prepare the technology validation documentation for technology infusion purposes. At this point, the IDPT process works in reverse to help achieve the desired technology infusion. That is, the technology transfer documentation, represented in a large part by this parent document that contains the validation results, is transmitted through the IPDTs back to the aerospace firms and instrument development organizations for incorporation into their proposals for future missions.

A perfect case of where EO-1 technology transfer and infusion has occurred is the Landsat Data Continuity Mission (LDCM) program. In this case, the total set of new technologies contained in the ALI instrument, the WARP, and the XPAA spacecraft technologies are prime candidates for being infused into the LDCM bidders’ proposed designs.