

New Millennium Program Earth Orbiter-1 (EO-1) Technology Level II Requirements



National Aeronautics and
Space Administration

————— Goddard Space Flight Center —————
Greenbelt, Maryland

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Earth Orbiter-1 (EO-1)
Technology Level II Requirements**

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Section 1. Introduction

This document contains the New Millennium Program (NMP)/Earth Orbiter-1 (EO-1) Technology Level II requirements. The EO-1 Technology Level II requirements specify and define requirements at the technology subsystem level. These requirements address technology subsystem level functional and performance specifications as well as interface requirements to the spacecraft and ground segments.

The EO-1 mission requirement definition is accomplished in three levels. The Level I requirements define the EO-1 mission objectives and products. The Level II requirements identify and allocate appropriate requirements to mission segments (Technology, Spacecraft, Ground Segment). The Level II requirements are top-level requirements for each mission segment. The Level III requirements are the lowest level requirements for the mission. The Level III requirements are directly implemented at the hardware and software levels. The Level III requirements are traced to Level II and then to Level I. All Level III requirements have either parent requirements in Level II and/or Level I, or have justification for their orphan status.

Section 2. Requirement Organization

Requirements are organized and identified by Requirement ID, Requirement Type, Requirement Title, and Requirement Statement. The Requirement ID is a numbering system where each requirement is assigned a unique number. This number is used in tracing a requirement from parent to child and vice versa. The Requirement Type is an indicator for the type of requirement. A detailed description of the Requirement Types is provided in the Section 3. The Requirement Title is a title for the requirement. The Requirement Statement provides the required action or activity. There is only one required action or activity per Requirement Statement.

The Level II requirements for the Technology segment of the EO-1 are given in Appendix A.

Section 3. Requirement Type Definitions

The requirement types are defined below.

H (Hierarchical) Requirement—A requirement that is not directly verifiable but provides structure to a set of requirements. A hierarchical requirement must be verified “through validation.” This means that the child requirements must be validated to define the success of the parent, and the child requirements must be verifiable.

NOTE: Child requirements may themselves be hierarchical.

FC (Functional Category)—A hierarchical requirement that is the parent of a set of child requirements. Generally the functional category may be viewed as a container of a set of requirements that are “alike” in some manner, such as

- a. Have similar functionality
- b. Have the same functionality applied to different elements
- c. Are verified as a group

F (Functional) Requirement—A requirement that is a child requirement to a functional category. A functional requirement is the parent requirement to performance requirements. Functional requirements specify functions of the system, subsystem, instrument, or component. Functional requirements must be verifiable by test, analysis, or inspection.

P (Performance) Requirement—A requirement that is a child requirement to a functional requirement. The performance requirements are directly verifiable, and each performance level is verified. The performance requirements specify discrete performance levels of the system, subsystem, instrument, and/or component. The verification methods for performance requirements are test, analysis, and/or inspection.

Section 4. Requirement Verification

The requirements shall be verified using methods accepted by the EO-1 mission management. The acceptable verification methods include testing, analyses, and/or inspection. Positive verification for each requirement shall be provided. A requirement shall be verified either directly or indirectly. An example of an indirect verification would be such that a Level I requirement is traced to Level II and then to Level III, where a direct verification of the Level III requirement is accomplished. In this case, the Level I and II requirements are verified indirectly, and the Level III requirement is verified directly. This is an acceptable verification approach.

Section 5. Requirements Verification Matrix

The requirements verification matrix shall be developed. The matrix shall identify the requirement, verification method, verification acceptable criteria, verification results, and date of verification.

Section 6. EO-1 System Validation

The requirements verification matrix, along with requirements tracing to either parent or child, shall be the basis for the EO-1 system validation.

Appendix A. NMP EO-1 Technology Level II Requirements

Requirement ID	Requirement Type	Requirement Title	Requirement Statement
01	H	NMP/EO-1 Technology: Level II	This document defines Level II requirements for the NMP EO-1 Technology.
01.01	H	General	All technologies shall adhere to the requirements in this section as applicable.
01.01.00.01	F	Mission Life	Shall be designed to support mission life of 1 year nominally and 18 months for expendables.
01.01.00.02	F	Technology Category "II"	Technologies that are in Category "II" shall have alternates ready at the time of EO-1 observatory integration and test.
01.01.00.03	F	Environment	All hardware and software shall adhere to EO-1 environmental requirements. (Reference: document SAI-SPEC-158)
01.01.00.04	F	Mission Assurance	All hardware and software shall adhere to EO-1 mission assurance requirements.
01.01.00.05	F	Verification	Shall provide for adequate visibility to accommodate effective subsystem and system functional and performance verification at all stages of development.
01.02	H	Multispectral Imaging Capability (MS/PAN)	Shall demonstrate superior multispectral imaging capability.
01.02.01	FC	Images	Shall ensure continuity of the Landsat 7 data set by collecting Landsat-type MS/PAN images.
01.02.01.01	F	Image Type	Shall gather Landsat-type multispectral terrain images.
01.02.01.02	F	Landsat-Type Spectral Bands	Shall gather Landsat-type spectral bands from 0.4 um to 2.5 um.
01.02.01.03	F	Prime Spectral Bands	Shall gather prime bands (TBS um).
01.02.01.04	F	Telescope	The telescope optomechanical performance shall provide unobstructed optics that allow substantially small focal plane diode.
01.02.01.05	F	Focal Plane	MS/PAN focal plane module shall demonstrate the mosaic of 4 Sensor Chip Assembly (SCA), each SCA having a spectrum band and pan band of 0.48 to 0.68 um.
01.02.02	FC	Calibration	Shall evaluate calibration capabilities.
01.02.02.01	F	Parameters	Shall support calibration goal of 5% radiometric for future missions.
01.02.02.02	F	Design	Shall have variable apertures, diffusers, and internal sources to support the calibration goals.
01.02.02.03	F	Calibration Sources	The Sun, Moon, and deep space shall be viewed during calibration.
01.02.03	FC	Paired Scene Comparison	Shall support 200 paired-scene comparisons with Landsat 7.

Requirement ID	Requirement Type	Requirement Title	Requirement Statement
01.02.03.01	F	On-Orbit Operation	The ALI FPE shall operate for 10 minutes maximum per daylight period of each orbit, up to four times per 24-hour period, with a minimum of 800 scenes per year.
01.02.03.02	F	Ground Formation Flying	Shall provide ground-based formation flying of sufficient precision (1 minute behind Landsat 7 and ± 3 km cross-track).
01.02.04	FC	MS/PAN Focal Plane Thermal Environment	Shall demonstrate non-cryogenic capability of the near and short wavelength infrared detectors.
01.02.04.01	F	HgCdTe Detectors	Shall demonstrate operation of HgCdTE detectors at the nominal 220 °K thermal environment.
01.02.04.02	F	Thermal Stability	Shall provide the necessary thermal stability to achieve stable focal plane detector operation.
01.03	H	Wide-Field, High-Resolution, Reflective Optics	Shall provide the basis for a Landsat equivalent multispectral swath width and resolution.
01.03.00.01	F	Optical Design	Optical design shall yield Landsat cross-track field with an in-track field to accommodate the detectors.
01.03.00.02	F	Optical Prescription	Optical prescription shall yield sufficient performance to support 10-m pan band.
01.03.00.03	F	Pushbroom Mode	Shall operate in pushbroom mode covering entire Landsat 7 swath of 185 km.
01.03.00.04	F	Cross-Track Coverage	MS/PAN focal plane sensor chip assemblies shall permit Landsat cross-track coverage with no gaps.
01.04	H	Silicon Carbide (SiC) Optics	Shall provide the basis for reflective optical systems that are light and stable over a wide range of operating temperatures.
01.04.00.01	F	Large Aperture Optics	Telescope shall demonstrate large aperture SiC optics.
01.05	H	Wedge Imaging Spectrometer (WIS)	Shall provide the basis for the future hyperspectral imaging system.
01.05.01	FC	Images	WIS images shall be collected.
01.05.01.01	F	Focal Plane Placement	WIS and GIS shall view the same ground track.
01.05.01.02	F	Ground Sample Distance	The ground sample distance shall be same as Landsat ground sample distance.
01.05.02	FC	WIS Data	WIS data shall be evaluated.
01.05.02.01	F	Data Synthesis	Shall synthesize Landsat data, 0.4 um to 2.5 um, with the WIS data.
01.06	H	Grating Imaging Spectrometer (GIS)	Shall be used to critically evaluate the time-dependent spectral sampling of the WIS.
01.06.01	FC	Images	GIS images shall be collected.
01.06.01.01	F	Focal Plane Placement	GIS shall view the same ground track as WIS.
01.06.01.02	F	FPA	GIS FPA design and data format shall allow for WIS-to-GIS comparison.
01.07	H	Atmospheric Corrector (AC)	The AC shall enhance land imaging.

Requirement ID	Requirement Type	Requirement Title	Requirement Statement
01.07.00.01	F	Image Collection	Shall collect TBD number of images to perform spectral and spatial characterization.
01.07.00.02	F	Calibration	Solar, lunar, and deep space scans shall be used for radiometric calibration.
01.07.00.03	F	Relative Pointing	Shall be capable of determining the relative pointing of the ALI and the AC as defined in ICD.
01.07.00.04	F	Operation	AC images shall be taken while MS/PAN images are being collected to provide end-to-end system validation.
01.08	H	Fiber Optics Data Bus (FODB)	The FODB shall serve as a data transmission media, electronics and protocol for science data between and ALI, the AC, and the WARP.
01.08.00.01	F	Data Transmission	The FODB shall provide high quality science data transmission through the FODB interface.
01.08.00.01.01	P	Data Rate	The FODB shall be capable of transferring at rates up to 1.0 Gbps.
01.08.00.01.01	P	Error Rate	The FODB error rate shall be 1.0E-09 or less.
01.09	H	X-Band Phased Array Antenna (XPAA)	The XPAA shall demonstrate lightweight antenna that is electronically steerable.
01.09.01	FC	Science Data Transmission and Link Error	Shall be capable of transmitting science data, and link error shall be established.
01.09.01.01	F	Science Data Transmission	Shall provide a 105 Mbps QPSK data link for science data return to Earth.
01.09.01.02	F	Bit Error Rate (BER)	Measurement and tabulation of basic BER shall be taken during technology validation.
01.09.01.03	F	Error Burst Length Data	Error burst length data shall be taken during technology validation.
01.09.02	FC	Antenna Pattern Scan	The antenna pattern scan shall be performed periodically.
01.09.02.01	F	Antenna Gain Measurements	Main lobe antenna gain measurements shall be taken on the ground and in space.
01.09.02.02	F	Controller	Shall demonstrate the reliability of the software and controller of the array.
01.10	H	Enhanced Formation Flying (EFF)	The EFF shall provide the autonomous capability of flying over the same ground track of another spacecraft at a fixed separation in time.
01.10.01	FC	Autonomy	The EFF shall provide onboard autonomous relative navigation and formation flying control for the EO-1.
01.10.01.01	F	AutoCon Flight Control System	The AutoCon flight control system shall provide autonomous formation flying control.
01.10.02	FC	Ground Track	EO-1 shall fly over the same ground track (± 3 km) as Landsat 7.
01.10.02.01	F	Separation	Shall maintain a 1-minute in-track separation between EO-1 and Landsat 7.
01.11	H	Light Weight Solar Array (LWSA)	The LWSA shall provide the basis for future lightweight solar panels.

Requirement ID	Requirement Type	Requirement Title	Requirement Statement
01.11.00.01	F	Deployment	Shall demonstrate a controlled deployment using Shape Memory Alloy hinges.
01.11.00.02	F	Efficiency	Shall demonstrate specific energies greater than 100 W/kg.
01.11.00.03	F	Dynamic Performance	Dynamic performance shall be evaluated using accelerometer during spacecraft yaw maneuver.
01.12	H	Carbon-Carbon Radiator (CCR)	The CCR validation shall provide the basis for radiators that are considerably lighter and have greater thermal conductivity than aluminum.
01.12.00.01	F	Thermal Conductivity	Thermal conductivity shall be evaluated.
01.12.00.02	F	Mechanical Properties	CCR mechanical properties shall meet the structural requirements of the spacecraft design.
01.12.00.03	F	Contamination	The CCR shall be encapsulated to preclude contaminating ALI.
01.12.00.04	F	Thermal Dissipation	Thermal dissipation shall be 60 W per ICD.
01.13	H	Pulsed Plasma Thruster (PPT)	The PPT validation shall provide the basis for a low mass, low cost, highly reliable, and safe propulsion system.
01.13.00.01	F	Control Capability	The PPT shall demonstrate the capability to replace all science mode functions of pitch wheel.
01.13.00.02	F	Demonstration	The PPT shall be demonstrated and validated after ALI has been validated.
01.13.00.03	F	Plume	Shall confirm that the PPT plume is benign to the optical surfaces of the ALI.

Abbreviations and Acronyms

AC	Atmospheric Corrector
ALI	Advanced Land Imager
BER	bit error rate
CCR	Carbon-Carbon Radiator
EFF	Enhanced Formation Flying
EO-1	Earth Orbiter-1
F	functional requirement
FC	functional category
FODB	Fiber Optic Data Bus
FPE	focal plane electronics
GIS	Grating Imaging Spectrometer
H	hierarchical requirement
ICD	interface control document
°K	degrees Kelvin
kg	kilogram
km	kilometer
LFSA???	Lightweight, Flexible Solar Array
m	meter
Mbps	megabits per second
MS/Pan	multispectral/panchromatic
NMP	New Millennium Program
P	performance requirement
PPT	Pulsed Plasma Thruster
QPSK	quadrature phase shift key
SCA	Sensor Chip Assembly
SiC	silicon carbide
TBS	to be supplied
um	

W	watt
WARP	Wideband Advanced Recorder/Processor
WIS	Wedge Imaging Spectrometer
XPAA	X-Band Phased Array Antenna