THE JOINT STAFF
WASHINGTON, D.C. 20318-8000

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JOINT REQUIREMENTS
OVERSIGHT COUNCIL

MEMORANDUM FOR THE UNDER SECRETARY OF DEFENSE FOR
ACQUISITION, TECHNOLOGY AND LOGISTICS

Subject: National Polar-orbiting Operational Environmental Satellite System (NPOESS) Integrated Operational Requirements Document-II

The Joint Requirements Oversight Council (JROC) reviewed and approved the NPOESS Integrated Operational Requirements Document-II and validated the Milestone B Key Performance Parameters (KPPs). The JROC considers the KPPs as essential to meet the NPOESS mission need.

PETER PACE
General, United States Marine Corps
Vice Chairman
of the Joint Chiefs of Staff

Enclosure

National Polar-orbiting Operational Environmental Satellite System (NPOESS)

Key Performance Parameters (KPPs)

System Requirement	Threshold	Objective
ATMOSPHERIC VERTICAL MOISTURE PROFILE (measurement uncertainty)		
Clear, surface to 600mb	Greater of 20% or 0.2g kg^{-1}	10%
Cloudy, surface to 600mb	Greater of 20% or 0.2g kg^{-1}	10%
ATMOSPHERIC VERTICAL TEMPERATURE PROFILE (measurement uncertainty)		
Clear, surface to 300mb	1.6K/1km layer	None
Cloudy, surface to 700mb	2.5K/1km layer	None
GLOBAL SEA SURFACE WINDS		
Measurement Accuracy (Speed)	Greater of 2m s^{-1} or 10%	Greater of 1m s^{-1} or 10%
IMAGERY (Refresh for visible and IR bands)	At any location: a) the avg. revisit time will be 4 hrs or less and the max revisit time will be 6 hrs or less; b) at least 75% of the revisit times will be 4 hrs or less	1 Hour
SEA SURFACE TEMPERATURE		
Horizontal Cell Size - Nadir, clear	1km	0.25km
Measurement uncertainty - clear	0.5° C	0.1° C
SOIL MOISTURE		
Sensing Depth	Surface (skin layer: -0.1cm)	Surface to –80cm
DATA ACCESS	Capable of selectively denying all US environ sensor data (except ARGOS and SARSAT)	None
INTEROPERABILITY	100% of top-level IERs designated critical	100% of top-level IERs

THE JOINT AGENCY REQUIREMENTS COUNCIL
National Polar-orbiting Operational Environmental
Satellite System (NPOESS)

10 Dec 2001

MEMORANDUM FOR THE NATIONAL POLAR-ORBITING OPERATIONAL SATELLITE SYSTEM EXECUTIVE COMMITTEE

Subject: NPOESS Integrated Operational Requirements Document-II

The Joint Agency Requirements Council reviewed and approved the NPOESS Integrated Operational Requirements Document-II.

Scott Gudes
Deputy Under Secretary of Commerce
for Oceans and Atmosphere

Ghassem Asrar
Associate Administrator for
Earth Science

Peter Pace
General, United States Marine Corps
Vice Chairman
of the Joint Chiefs of Staff

Enclosures

INTEGRATED OPERATIONAL REQUIREMENTS DOCUMENT (IORD) II

December 10, 2001

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

ACAT LEVEL 1D

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NPOESS Integrated Operational Requirements Document

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INTEGRATED OPERATIONAL REQUIREMENTS DOCUMENT

FOR

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)
ACAT 1D
Prepared for EMD/Production Milestone Decision

1.0 General Description of Operational Capability

1.1 Mission Needs

The U.S. Government (USG), specifically the Department of Commerce’s (DOC) National Oceanic and Atmospheric Administration's (NOAA) and Department of Defense's (DoD) environmental missions, requires an enduring capability to acquire and receive in real time at field terminals, and to acquire, store and disseminate to processing centers, global and regional meteorological, environmental, and associated data at varying refresh rates. These data shall include, but are not limited to: information on imagery, atmospheric profiles of temperature and moisture, and other specialized meteorological, terrestrial, climatic, oceanographic, and solar-geophysical data, as well as a search and rescue capability, to support world-wide USG (Military and Civil) operations and high-priority programs.

The USG requires regular and reliable global imagery and quantitative atmospheric, oceanic, land, solar and space environmental measurements in support of (not in priority order): 1) aviation forecasts (domestic, military, and international); 2) medium range forecast outlook (out to fifteen days); 3) tropical cyclone (hurricane reconnaissance and warnings); 4) severe storm and flood warnings; 5) forecasts of ice conditions; 6) solar and space environmental forecasts; 7) hydrologic forecasts; 8) forecasts of the ocean surface and internal structures; 9) seasonal and interannual climate forecasts; 10) decadal-scale monitoring of climate variability; 11) assessment of long-term global environmental change; 12) environmental air quality monitoring and emergency response; 13) tactical decision aids; and 14) weapon systems utilization.

The NOAA Polar-orbiting Operational Environmental Satellite (POES) and the Defense Meteorological Satellite Program (DMSP) meet many U.S. needs for remote environmental sensing. The National Polar-orbiting Operational Environmental Satellite System (NPOESS) will be a replacement program for the POES and DMSP Follow-On systems. During the NPOESS era, Europe plans to fly operational polar-orbiting satellites under their Meteorological Operational (METOP) program. To minimize cost to the USG, the NPOESS Integrated Program Office (IPO) will determine the optimum level of utilization of METOP in meeting some USG requirements, such as refresh rate.

1.1.1 Requirements and Mission Needs Document Summary. DOC and DoD require global and regional environmental data which includes cloud imagery, atmospheric profiles and other specialized meteorological, oceanographic, climatic and solar-geophysical data to provide forecasts, advisories and warnings to support civilian and military operations as well as national programs. DoD's need for this information is documented in the Air Force Space Command (AFSPC) Mission Need Statement (MNS) 035-92 for Environmental Sensing, validated 6 January 1993. DOC's need for this information is documented in the Department of Commerce, National Oceanic and Atmospheric Administration 1995-2005 Strategic Plan, dated 15 July 1993, and Public Law 15 USC 313 "Organic Act".

Other specific DoD mission needs documents are listed in Appendix A.

A requirements determination analysis (process analysis) was completed and nonmaterial alternatives were judged to be inadequate.

1.2 Mission Area

NPOESS supports the operational needs of the civilian meteorological, oceanographic, environmental, climatic and space environmental remote sensing programs and Global Military Environmental Support, for Geophysical and Space Support. In addition, NPOESS supports the National Space Act of 1958 and the Presidential Decision Directive (PDD)/NSTC-2, dated May 5, 1994 and promotes a positive international image for the United States Government.

1.2.1 Related Capstone Requirements Documents

There are no Capstone Requirements Documents (CRDs) for weather systems that directly relate to NPOESS. However, since NPOESS transmits information and has indirect connection with the Global Information Grid (GIG), the NPOESS IORD was crosswalked with the GIG and Information Dissemination Management (IDM) CRDs. Crosswalk linkages are tabulated in Appendix D.

1.3 Proposed System

The NPOESS Program is required to provide, for a period of at least 10 years, a 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, solar-geophysical and other data in support of DOC mission requirements and DoD peacetime and wartime missions. The NPOESS Program has four segments: 1) Space; 2) Launch Support; 3) Command, Control, and Communications (C^3); and 4) Interface Data Processor (IDP) segments for both Centrals and field terminals (Figure 1.3-1). This notional NPOESS architecture is based on a Cost and Operational Benefits Requirements Analysis of original IORD requirements conducted in 1996. Standardization (which includes compatibility, interoperability, interchangeability and commonality) of DoD, DOC, and NASA systems, components and interfaces, will be a primary goal of the NPOESS program

1.3.1. Space Segment. The Space Segment will consist of meteorological, oceanographic, terrestrial, space environmental monitoring and climatic sensors, in addition to other systems for surface data collection/location and search and rescue. The Space Segment will include platforms for sensors which will collect and transmit environmental and other data in real time to field terminals (receivers used by deployed/remote units to obtain environmental data). In addition, the Space Segment will collect and store environmental data and other data until it can be downlinked directly to the C^3 Segment.

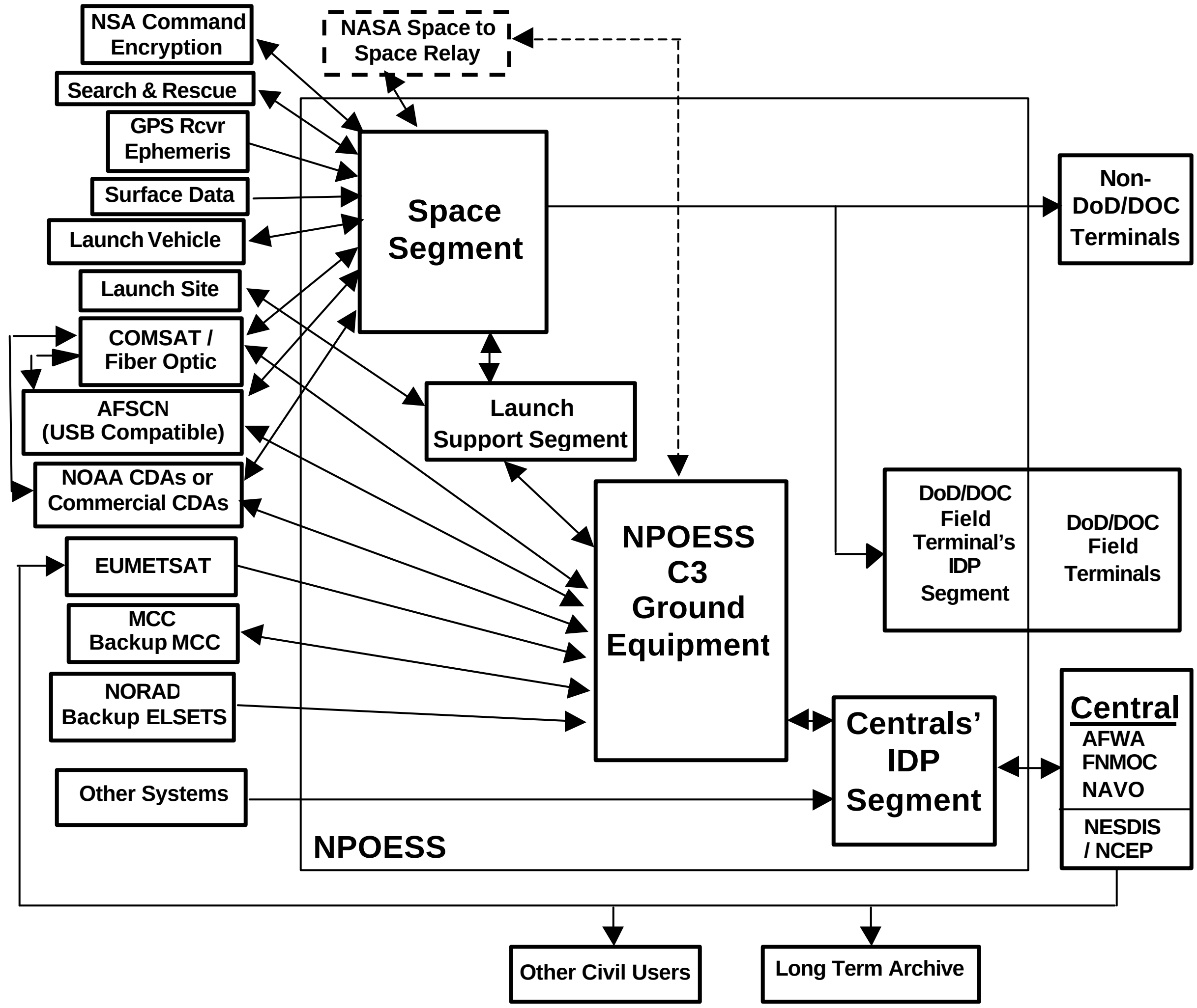

Figure 1.3-1 - NPOESS Notional Functional Diagram

To meet the requirements from DoD, DOC and national and international agreements, the NPOESS Program shall have the capability to simultaneously broadcast two types of "real-time data" to suitably equipped ground stations. The first, the High Rate Data (HRD) broadcast, is a complete, full resolution data set (or an appropriate subset) containing all sensor data and auxiliary data necessary to generate all NPOESS EDRs and is intended for regional hubs and users. The second, the Low Rate Data (LRD) broadcast, is a subset of the full data set and is intended for field terminal users. Some data compression (Lossy or Lossless) may be employed for the LRD link. Notionally, the spacecraft shall provide this real-time data to field terminal components (land and ship-based, fixed and mobile environmental data receivers operated by USAF, United States Navy (USN), United States Marine Corps (USMC), and United States Army (USA), and surface receivers operated by DOC, other USG agencies and world wide weather services). Future communications capabilities may allow other-than-direct data transmission to follow-on field terminal systems.

1.3.2 Launch Support Segment. The Launch Support Segment includes all launch support equipment including Aerospace Ground Equipment (AGE), additional ground test equipment, Real Property Installed Equipment (RPIE) and launch facilities. AGE consists of computer checkout systems and other equipment to support satellites prior to launch. RPIE includes items such as power equipment, air conditioning equipment and non-flight fuel stores. The launch facilities include payload test facilities and other required equipment and facilities to place the spacecraft into operational orbit.

1.3.3 Command, Control, and Communications (C^3) Segment. The NPOESS C^3 Segment shall include all functions required for mission management, day-to-day operations and state-of-health monitoring of all operating NPOESS spacecraft and support of the delivery of data to the designated Centrals. Real-time data shall be provided to users via a real time communications link between the spacecraft and field terminals.

The NPOESS C^3 Segment consists of shared and dedicated C^3 resources such as antennas, communication links, and other command and control equipment needed to fulfill the NPOESS mission. Spacecraft simulators are also considered part of the C^3 Segment. The C^3 Segment shall consist of a cost effective mix of government and/or commercial C^3 assets.

C^3 resources/nodes that (1) meet NPOESS operational requirements, (2) are operated in accordance with appropriate international agreements or treaties between the U.S. and the host nation, and (3) have a U.S. government presence or an acceptable commercial contract in place, are considered under U.S. control for the purposes of this program. If one or more C^3 resources/nodes do not meet the above “U.S. controlled” criteria, then the overall C^3 architecture shall have sufficient capability to meet the threshold NPOESS requirements without reliance on any one such resource/node (*e.g.*, a single non-US controlled node becomes unavailable for operations).

1.3.4 Interface Data Processor (IDP) Segment. The IDP Segment consists of data processing functions that meet the requirements of Centrals and field terminals. Software commonality will exist between the IDP Segment and the field terminals to the maximum extent possible. All IDP Segment installations shall consist of the hardware and software necessary to receive and process raw data into the data products required in Table C. - NPOESS Environmental Data Record (EDR)/Raw Data Record (RDR) Matrix. Processing RDRs into Environmental Data Records (EDRs) will require production of intermediate-level satellite instrument data files called Sensor Data Records (SDRs) and Temperature Data Records (TDRs). The requirement for the SDRs/TDRs is for user displays, retrospective processing leading to improved methods, and for sensor evaluation, trending or troubleshooting. The TDRs contain the counts and calibration data at geolocated points. The calibration data and counts in the SDRs and TDRs provide reversible data necessary to recreate RDRs for validation purposes. This intermediate-level data needs to be available as retrievable data records. This data is vital when validating the data, determining data quality and in data quality resolution.

Data shall be delivered to the Centrals' IDP Segment and HRD field terminals' data processing elements as RDRs. Throughout this document, production of EDRs includes production of SDRs/TDRs, as needed.

Other federal, state and local agencies, universities/academia, and industry, on a worldwide basis, shall also be able to access NPOESS real-time broadcast and archived data. NPOESS shall be designed to meet user needs with minimum impact to existing receiver terminals and procedures.

1.3.5 Ancillary Data and *In Situ* Networks. Ancillary data are necessary for the calculation of retrievals for some EDRs. Such data are generally acquired by *in situ* networks, which are operated by the USG. Other uses of *in situ* networks (DOC, NASA) for NPOESS pertain to sensor calibration and validation of EDR accuracy and long-term stability requirements, which will be described in a future calibration/validation document (see section 4.1.6). NPOESS shall leverage the existing USG resources and shall coordinate the requirements for the availability and quality of these data sources with the appropriate agencies.

1.4 Tasked Missions

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) supports the operational needs of the civilian meteorological, oceanographic, environmental, climatic, and space environmental remote sensing programs, and Global Military Environmental Support.

1.5 Operational and Support (including Information Exchange) Concepts

The USG NPOESS space segment shall be controlled by the C^3 Segment. The METOP portion of NPOESS will be controlled by EUMETSAT with a backup capability controlled by NOAA in accordance with Initial Joint Polar System (IJPS) agreements. The operational concept for the NPOESS Program is for the space segment to collect space, climatic, meteorological, terrestrial, solar geophysical, oceanographic and other environmental data then deliver the data to the IDP Segment located at field terminals and centralized processing centers. All sensed data will be recorded (at its optimum resolution) and transmitted to the Command and Data Acquisition (CDA) sites and forwarded to the IDP Segments at the centralized processing facilities. The IDP Segment shall convert RDRs to EDRs. (Table C provides the current notional data requirements at the Centrals and field terminals). The Centrals and field terminals then integrate the NPOESS products into weather and other environmental products for transmission to end users. The NPOESS responsibilities for data handling/manipulation/distribution end with the passing of data from the IDP Segment to the users at the Centrals and field terminals.

Due to the concentration of expertise in specific sensor-types/parameters at the Centrals, and the necessity to interface the IDP Segment into their architecture, the Centrals should participate, to the maximum extent possible, in the IDP Segment operation and algorithm upgrades. While NPOESS is not constrained by the structures of the POES and DMSP programs, it is desirable to emulate and incorporate successful models of cooperation and shared responsibility, such as the Shared Processing Program, into the NPOESS concept of operations.

The NPOESS IPO will operate the primary Satellite Operations Center (SOC) at the DOC facility at Suitland, MD as part of the C3 segment. This SOC will be responsible for performing the operational functions of satellite command and control, mission planning/management, data network enterprise management, antenna resource scheduling, launch and early orbit operations, anomaly resolution, data access and the relay of data to Centrals through the Data Routing and Retrieval network.

The responsibility for satellite control resides with the NPOESS/IPO System Program Director (SPD). The Satellite Control Authority (SCA) is the authority to direct, approve or delegate satellite command and control operations to maintain a specific satellite in a safe operating configuration, take actions necessary to "safe" a satellite and to implement approved satellite hardware and software reconfigurations. This authority may be delegated by the SPD to the Associate Director for Operations (IPO/ADO) who has responsibility for the NPOESS SOCs. Thus, the SCA will notionally reside within the SOCs.

A backup SOC will be operated at Schriever AFB, CO by the DoD using a cost effective mix of contractor and USAF Reserve personnel. This backup SOC will be capable of performing the same operational functions as the primary SOC with the exception of launch and early orbit operations. The backup SOC will assume primary operational responsibility for NPOESS upon direction of the SCA or determination that primary SOC is unable to perform operational functions (i.e., loss of contact).

1.5.1 <u>Space Segment</u>. The Space Segment shall continuously observe, store and forward required environmental data to the Centrals' IDP Segment. Real-time data are also continuously broadcast to users within the satellite field of view.

1.5.2 <u>Launch Support Segment</u>. The Launch Support Segment will be provided jointly by DoD/DOC, as appropriate.

1.5.3 <u>C^3 Segment</u>. NPOESS Data, including RDRs, SDRs, EDRs, stored raw mission data, stored and real-time telemetry, and stored Surface Data Collection data, will be distributed through the Data Routing and Retrieval (DRR) Element of the C^3 Segment to the Centrals which are: Air Force Weather Agency (AFWA), Fleet Numerical Meteorology and Oceanography Center (FNMOC), Naval Oceanographic Office (NAVOCEANO) and National Environmental Satellite, Data, and Information Service (NESDIS)/National Centers for Environmental Prediction (NCEP). DoD and DOC, not the NPOESS program, will have responsibility for distribution of NPOESS data and products to their respective user organizations below the Central level. EUMETSAT requirements concerning data sharing and timeliness are to be included in international agreements.

1.5.4 <u>IDP Segment</u>. This segment shall have the capability to receive and store raw data, process EDRs as necessary, make EDRs available to Centrals' and field terminal processors and allow retrieval of NPOESS data by Centrals' and field terminals.

1.5.4.1 <u>Centrals' IDP Segment</u>. The Centrals' IDP Segment shall store the raw data, process them into EDRs (as indicated in Table C), using auxiliary and ancillary data as necessary, and store the data. The specific Centrals/IDP Segment interface requirements will be defined in a future Interface Control Document (ICD). Centrals may provide the data to local systems and other users, as required. Other users may also have an independent reception capability. The processing, archiving, and dissemination of these data by independent users are their responsibility.

1.5.4.2 Field Terminal IDP Segment. Requirements for Field Terminals, to include IDP Segment functions, are discussed in paragraph 5.6.5.

1.6 Evolutionary Acquisition. NPOESS will use Evolutionary Acquisition for two purposes: risk reduction and increasing system capabilities after Initial Operational Capability (IOC). Risk reduction will be performed throughout the program via competitive sensor developments and early flights of opportunity. Increasing system capabilities will be done via the potential Pre-planned Product/Process Improvements (P^3I) process.

2.0 Threat

The threats to NPOESS are discussed in the following classified DIA-validated documents: Space Systems Threat Environment Description (U), , NAIC-1571-0727-01, January 2001, S/NF/MR and the Defense Meteorological Satellite Program/National Polar-Orbiting Operational Environmental Satellite System, System Threat Assessment Report (U), NAIC-1574-0110-01 April 2001 (S//NF//MR).

2.1 Operational Threat Environment

See DMSP/NPOESS STAR for details on countries that have the capability, or potential capability to threaten NPOESS, and how NPOESS would be threatened under the Middle East and Korean peninsula scenarios.

2.2 System Specific Threats

The most likely threats against NPOESS fall into four main categories. The first is Information Warfare (IW), which encompasses network vulnerabilities, Electronic Warfare (EW) and exoatmospheric nuclear bursts. The second is the threat from anti-satellite (ASAT) directed energy weapons (DEWs), to include lasers, radio frequency weapons and neutral particle beam weapons. The third is the threat from ASAT kinetic energy weapons (KEWs). The fourth is the threat to NPOESS terminal control segments from conventional, unconventional, and non-military forces. See DMSP/NPOESS STAR for details.

2.3 Reactive Threat

The reactive threat is an assessment of changes to the threat environment that could reasonably be expected to occur as a direct result of the development and deployment of NPOESS. No reactive threats are anticipated. See DMSP/NPOESS STAR for an explanation.

3.0 Shortcomings of the Existing Systems and C4ISR Architectures

The DMSP and POES legacy systems combine to partially address the current needs for global environmental data for the DoD and DOC. Constraints in the legacy systems (*e.g.*, C^3 and DRR subsystems) cannot support the NPOESS era requirements for resolution, refresh, or timeliness. The existing DOC capability to satisfy the requirements is primarily through NOAA's POES plus leveraging of other satellite programs such as DMSP, and national and international satellites like the NASA-French Topex/Poseidon (T/P), SeaWIFS, EOS, USGS Landsat, and the European Space Agency's (ESA) ERS-series, TRMM, and QuickSCAT. DMSP is DoD's primary source of satellite environmental data. DoD agencies also leverage national and international data to augment DMSP capabilities. Replacement polar orbiting satellites are needed to sustain capabilities beyond 2012. Lifetime probability predictions of the current space segment of DMSP (5D-2/5D-3 series satellites) and POES indicate that these series of satellites will be capable of supporting the mission requirements only through 2008 (POES) and 2012 (DMSP). Legacy systems do not directly interface with C4ISR systems. The following are some shortcomings associated with these systems:

1) Current systems do not meet sensor coverage requirements for contiguous global coverage for certain parameters.
2) Current systems do not meet operational requirements for data refresh.
3) Data latency times exceed operational needs. Data often exceeds two hours from the time measured until the data are available for use at national forecasting centers.
4) Current sensors cannot meet vertical and horizontal resolution requirements.
5) Current sensors cannot meet requirements for all operational required environmental data records.
6) Current satellite size, weight, and power do not permit expansion for new sensors.

3.1 Space Segment

The current POES and DMSP systems maintain no growth capability for areas such as power, payload capacity, data throughput, weight, or autonomy. Planned sensor manifests for DMSP 5D-3 and NOAA K, L, M series of satellites make maximum use of available power, weight, and data processing, leaving no possibility for growth. The current DMSP system has the capability to collect day and nighttime fine resolution data. However, the capacity of on-orbit data storage and data transmission rates limit the quantity of fine resolution data from DMSP and high resolution data from POES which can be stored for subsequent transmission to the ground. The current mapping accuracies do not meet requirements, posing a limitation to the application of infrared (IR) and visible resolution capability. Mapping error is incurred by uncertainties in spacecraft internal alignment, attitude control, ephemeris prediction, and ground data processing.

Current DMSP and POES mission sensors do not meet all resolution and accuracy requirements stated in this IORD, nor do they provide the swath width (sensor's viewing footprint) required to provide contiguous global data for certain parameters. These shortcomings result in a lack of contiguous data near the equator which limits its usefulness in tropical storm and small-scale forecasting, and increases the period of time it takes for the satellite to provide global refresh of data. The orbital precession of POES satellites compromises data continuity. Finally, the current systems downlink stored data to ground stations with an average delay of over 50 minutes (oldest data delayed more than 102 minutes). This increases the delay in providing forecasts to customers.

Given the perishability of environmental data, the refresh inadequacies present a severe limitation to improving forecast accuracy and timeliness. With the current DMSP and POES systems, the data refresh rate ranges from 15 to 415 minutes, due to unequally spaced orbits. This results in DoD theater components providing customer support based upon data that are hours old. Local phenomena may develop and dissipate prior to receipt of the sensed data at the Centrals and field terminals.

3.2 C^3 Segment

The current approach to DMSP C^3 Segment software support is limited and not responsive to support requirements, leading to a disjointed process. In addition, the current DMSP system maintains only one communication path for the recovery of mission data. The current Space-Ground Link System (SGLS) and Data Retrieval and Routing (DRR) System does not provide sufficient bandwidth to support the high data rate downlink requirements of the current system. Any improvements in data delivery, such as the ability to downlink mission data more than once per revolution as well as multiple mission data routing paths, would result in direct improvements in forecasts and weapons employment. Finally, the current system is at or near capacity and currently programmed modifications to AFSCN site availability further exacerbate this shortfall.

NOAA's current C^3 Segment does not permit continuous mission data recovery, resulting in uncommanded orbits (up to 4 out of 14 per day) and potentially lost or untimely data.

3.3 IDP Segment

Current capacity to ingest data into its central computer processing system, convert these data to products to satisfy user demands, and deliver to the users, is sized for legacy DMSP and NOAA instruments. Upgrades are needed to both DOC and DoD Centrals and field terminals in the NPOESS era to meet an increased data volume and the EDR requirements stated in paragraph 4.1.6.

4.0 Capabilities Required

NPOESS shall collect and disseminate timely environmental data to all Centrals and field terminals worldwide. NPOESS will be a replacement program for the POES and DMSP follow-on systems providing enhanced capabilities to satisfy existing requirements. Specific system capabilities are stated in the following paragraphs.

Table A – ORD KPP Summary

KPP	Threshold and Objective
***Interoperability** All top-level IERs (Table B) will be satisfied to the standards specified in the threshold (T) and objective (O) values	100% of top-level IERs designated **critical** (T) 100% of top-level IERs (O)
*** Data Access KPP**	Selectively deny environmental data (T,O)
***Atmospheric Vertical Moisture Profile**	See 4.1.6.1.1, d.1 and d.4
***Atmospheric Vertical Temperature Profile**	See 4.1.6.1.2, d.1 and d.5
***Global Sea Surface Winds**	See 4.1.6.1.3, d.1
***Imagery**	See 4.1.6.1.4, a. and c.
***Sea Surface Temperature**	See 4.1.6.1.5, a. and e.
***Soil Moisture (Surface)**	See 4.1.6.1.6, a.

4.1 System Performance

NPOESS shall sense, collect, and disseminate full-earth-coverage environmental information in both wartime and peacetime in accordance with data refresh and timeliness requirements. During contingencies or periods of heightened tensions, NPOESS may be directed, by the National Command Authority to invoke Data Denial mode. Individual segments shall adhere to a common system architecture to the maximum extent possible. System performance parameters such as measurement ranges, accuracy and timeliness, and mission reliability, maintainability and availability (RMA) requirements, as well as other required capabilities are broken out by segment below. When in an autonomous mode (*i.e.*, satellite operating without updated command/control instructions), NPOESS shall continue to provide data to the Centrals and field terminals.

4.1.1 Space Segment. The Space Segment will provide platforms for sensors that will collect and store environmental and other data (except search and rescue) until the data can be downlinked to field terminals and to the C^3 Segment. Future communications capabilities may allow other-than-direct data transmission to follow-on Field Terminal systems, provided the requirements of timeliness and guaranteed reception are met.

4.1.1.1 Mission Payload Characteristics. Mission data shall be collected by multiple sensors employing diverse technologies to satisfy system requirements. These sensors will be located on one or multiple spacecraft. Data collection requirements may be met by either direct or remote sensing of required parameters, or derivation from sensed information. Imagery and vertical profiler sensors will be a combination of optical and microwave multi-spectral imagers/sensors. Each sensor generating data in multiple discrete channels (*i.e.*, spectral bandpasses, microwave frequency ranges, *etc.*) shall be capable of eliminating one or more channels from its output data stream by command. This capability allows exclusion of data that is degraded, contaminated or not desired for other reasons. Other sensors shall monitor earth radiation budget, space environmental, ocean/water, and land parameters that are described in Section 4.1.6.

4.1.1.2 Other Payloads. NPOESS shall provide transponders enabling surface data collection and location services (*i.e.*, ARGOS or its follow-on) plus the capability to provide search and rescue functions (*i.e.*, Search and Rescue Satellite Aided Tracking - SARSAT).

4.1.2 Launch Support Segment. The Launch Support Segment will provide resources, as appropriate, to accomplish launch operations and put each satellite into the correct orbit.

4.1.3 C^3 Segment. Under the NPOESS program, the hardware and software located at the IPO Primary SOC, and at the Backup SOC shall ensure a seamless transition from legacy to NPOESS operations. This seamless transition shall also apply to backup operations, continuity of data flow and processing, and ease of maintenance. The NPOESS Primary and Backup SOC shall have functionally identical computer system architectures and specific programs that are operated and maintained using the same commands and procedures. C3 Segment processes shall be modular to reduce maintenance and promote reusability. The C^3 equipment shall be in place and operational at the IPO Primary and Backup SOCs prior to launch of the first NPOESS satellite. This segment also includes all spacecraft simulators.

The NPOESS C3 segment shall deliver Stored Mission Data (SMD) at its optimum resolution to Centrals and High Rate Data (HRD) at its optimum resolution to HRD field terminals. If data compression techniques are used for SMD and HRD transmission, the compression shall be lossless. Low Rate Data (LRD) may be delivered at reduced resolution and may include use of lossy compression techniques.

4.1.4 IDP Segment. The IDP Segment shall have the ability to receive raw mission data from the C^3 or Space Segments (as appropriate for Centrals or field terminals), process the RDRs into EDRs (as required in Table C), and store RDRs, SDRs, TDRs, EDRs, and surface data collection/location data in a database management system. The design of the IDP Segment will not preclude, but will minimize the use of other external data sources in generating EDRs. The IDP Segment shall have sufficient temporary storage capacity to store the RDRs/SDRs/EDRs and ancillary data until the data can be delivered to the IDP Segment/Central interface for use in the Central's application (24 hour minimum). Therefore, the IDP Segment needs to have the capacity to store multiple passes. IDP Segment processes shall be modular to reduce maintenance and promote reusability. At final design, the IDP Segment shall be designed to permit 100% growth of the projected Full Operational Capability (FOC) storage and processing capacity.

4.1.5 System Characteristics. The agency shown in the headings of the following paragraphs is the primary user of that parameter. Where more than one agency name is listed, the agency name which appears first generally has the more stringent requirement. The parameters and sub-parameters noted with an asterisk **(*)** and **bold** type are those to be included in the Acquisition Program Baseline as key performance parameters (KPPs). KPPs are those parameters so significant that failure to meet the threshold is cause for the system to be reevaluated or the program to be reassessed or terminated.

4.1.5.1 Data Latency and Availability (DoD/DOC)

4.1.5.1.1 EDR Latency to Centrals. EDR latency is defined as the period from the Time of Observation of all requisite data by the satellite until the EDR produced by that data is available at the IDP Segment/Central interface. DoD and DOC require that 95% (threshold) and 99.8% (objective) (on a monthly average) of the observable data collected by each NPOESS satellite shall be delivered to the Centrals per the EDR latency requirements specified in Section 4.1.6. In a missed pass scenario, all data shall be recovered on subsequent passes. Recovery of missed data shall not impact the delivery of data that can still meet EDR latency requirements.

4.1.5.1.2 Data Availability to Centrals. DoD and DOC require that 99% (threshold), and 100% (objective) (on a monthly basis) of the data collected by operational sensors on each NPOESS satellite shall be delivered to the IDP Segment.

4.1.5.1.3 Data Availability to Field Terminals. NPOESS satellites shall continuously transmit HRD/LRD data in real time for acquisition by any suitably equipped field terminal.

4.1.5.2 Autonomous Operations (DoD). The spacecraft shall have an autonomous operations capability which maintains the ability to provide real-time mission data without C^3 contact for a period of at least 21 days (60 days objective) with a mapping uncertainty threshold of no greater than 45 km (1 km objective), to DoD field terminals. All storing of mission sensor data and transfer of stored data to ground receivers may be affected, but real-time transmissions shall not be affected by autonomous operation. Each satellite shall be capable of being commanded into autonomous operation, and shall automatically transition into autonomous operation in the event that ground contact is lost. Each satellite shall be capable of performing housekeeping tasks without ground contact. When transition to autonomous operation occurs, satellites shall automatically begin transmission of data in the data denial mode. Each satellite shall also maintain a historical record of autonomous events to the extent necessary to enable reconstruction of the decisions made and methods used by the satellite while in the autonomous mode. In addition, ground override of any autonomous function shall be provided.

4.1.5.3 Surface Data Collection/Location (DOC/DoD). As a threshold, NPOESS shall host a capability to geolocate data sources and/or collect data from globally deployed environmental sensor platforms, such as drifting buoys, for real-time transmissions to selected field terminals. Such data shall also be stored for relay to Centrals.

4.1.5.4. Orbital Characteristics (DoD/DOC). NPOESS shall be designed so that the same latitude is imaged/measured at approximately the same local solar time (LST) each day. As a threshold, NPOESS will fly at nominal equatorial crossing times of 1330, 1730, and 2130 (ascending) with an objective of having the capability of flying at any equatorial crossing time provided that sunlight is kept off the cold side of the spacecraft. The orbit shall be a "precise" orbit (i.e., maintained to fulfill mission requirements such as nodal crossing times maintained to $\pm$ 10 minutes throughout the mission lifetime.)

4.1.5.5. Orbital Characteristics for Sea Surface Height Measurement (DoD). For the purpose of Sea Surface Height measurement, the sensor will be flown in an orbit allowing a ground track repeat of ± 1 km.

4.1.5.6 System Survivability (DoD). See IORD Attachment 2.

4.1.5.7 Search and Rescue (DOC). DOC requires the NPOESS Program to be operationally compatible with and carry specific receivers, transmitters, *etc.*, necessary to fulfill DOC's international agreements (Russia, Canada, U.S., France, COSPAS (Russian search and rescue satellite system)/SARSAT agreement, 1 Jul 1988, as amended) for search and rescue (i.e., determine emergency transmitter locations).

4.1.5.8 Compatibility (DOC). Other federal, state, and local agencies, universities/academia and industry, on a worldwide basis, shall also be able to access NPOESS data. NPOESS development will consider these users in addition to DOC users and NPOESS will be designed to be compatible, where practical and economical, to meet user needs with minimum impact to existing receiver terminals and procedures, as a threshold.

4.1.5.9 Space Debris Minimization (DoD/DOC). The NPOESS satellite shall be designed so that measures may be taken to minimize space debris to the maximum extent possible. As a minimum, this will be IAW the 1997 NASA/DoD developed U.S. Government Orbital Debris Minimization Standard Practices, based on existing NASA Safety Standard 1740.14, and UPD 10-39, Satellite Disposal, and the National Space Policy, September 19,1996.

4.1.5.10 *Data Access (*DoD). As a threshold, the NPOESS shall be **capable of selectively denying all U.S. environmental sensor data (excepting ARGOS and SARSAT**) which are a part of the NPOESS constellation, during contingencies or conflicts.

4.1.5.11 * Interoperability (*DoD). NPOESS system interfaces (Interface Data Processor (IDP) Segment) shall be interoperable with the systems with which that they communicate. This includes the physical and electrical interfaces with equipment at the USG Centralized Facilities, the HRD and LRD Field Terminals and the Radio Frequency (RF) interfaces to various DoD and civilian nodes. Interoperability includes hardware and software compatibility with communication protocols and formats at the NPOESS to DoD system interface point. For this system this point is the IDP Segment hardware and software at the Centrals and the IDP Segment software at the field terminals. NPOESS to user community interfaces are shown in Figures 5.3-1 and 5.3-2. Table A specifies the Interoperability KPP and Table B contains the top level interoperability Information Exchange Requirements.

4.1.5.11.1 Interoperability Certification. Certification is intended to provide total life-cycle oversight of user interoperability requirements and to validate that the interoperability KPP was adequately tested. Interoperability certification will be conducted using approved DoD procedures.

4.1.5.12 Geolocation of Data (DOC/DoD). NPOESS satellite location and attitude information shall be provided with environmental data, as a threshold, to accurately locate the data source using the current Government-accepted version of the World Geodetic Standard ellipsoid. The NPOESS EDRs shall be referenced to a currently accepted digital elevation model, such as DTED Level II.

4.1.5.13 Space Environmental Constellation Characteristics (DoD/DOC). Space environmental parameters shall be measured as detailed in Section 4.1.6. Additional information on Space Environmental Constellation Characteristics is located in the Requirements Correlation Matrix (RCM) Part II (Attachment 1).

4.1.5.14 Information Integrity. NPOESS data communications links shall maintain and guarantee during transport the integrity of all information elements exchanged. Information integrity shall be at least 99.99% (with an objective of 99.999%).

4.1.6 Performance Characteristics. For both DoD and DOC, the final output products of their Centrals are accurate forecasts and analyses of environmental conditions to enhance various military and civilian operations. These forecasts are prepared using data from multiple systems, including NPOESS. DOC and DoD operational requirements are data values to be used as inputs to computer algorithms in order to create final forecast products for customers. The following environmental data record (EDR) requirements define the environmental data to be derived from the NPOESS data stream and delivered to users to meet mission needs. EDR parameters listed in 4.1.6.1 include attribute thresholds (and their justifications in RCM-II) which characterize satellite sensor data requirements.

DOC and DoD require RDRs, SDRs, and (for microwave sensors) TDRs that possess performance characteristics consistent with the EDRs derived from them. Centrals may use RDRs, SDRs, TDRs, or EDRs and satellite auxiliary data for other applications since these possess the full information content from the NPOESS constellation.

Parameter thresholds are cited first and objectives are cited second in the following paragraphs. Note that thresholds and objectives listed refer to the minimum requirement at any point where measurements are sensed, (*e.g.*, a requirement for horizontal resolution of 25 km indicates a need for data at that resolution or better across the entire area where data are being measured, unless specifically indicated at nadir (direct overhead view) or worst case (normally at the edge of satellite field of view) resolution separately). Any requirement giving “nadir resolution” as an attribute presumes that the expansion of the resolution at oblique viewing angles is a natural outcome of observing a sphere from space, and does not presume a specific scanning methodology. In these instances, technology will be driven by the nadir, or highest quality, field of view.

Global coverage denotes the observation of all points on the Earth or its atmosphere at least once per given time period (consistent with observational requirements).

Data products are required during any weather conditions; however, EDR requirements apply to clear conditions only unless otherwise specified. Thresholds given for attributes broken into “cloudy” (greater than or equal to five-tenths cloud cover), “clear” (less than five-tenths cloud cover), and “all weather” (all cloud conditions and rainfall rates less than 2 mm hr^{-1} km^{-2} unless otherwise specified in individual EDRs) cases indicate the government’s recognition that different technologies shall be employed to provide accurate measurements under these three different atmospheric conditions. Threshold value differences among cloudy, clear, and all weather cases demonstrate how the most stringent of the three is required when obtainable, and will add important information in the ultimate operational application of the data.

All data are required at the uncertainty/refresh/resolution stated, for any Earth location/profile. The performance characteristics for the EDR attributes of Vertical Coverage, Measurement Range, Vertical Reporting Interval and/or Vertical Cell Size, and Measurement Precision and Accuracy shall be within the normal/expected sensing range unless specifically indicated otherwise for each EDR.

USG requires that NPOESS instrument engineering data be delivered with the data streams so changes in responsivity, noise, and other parameters requiring ground processing corrections can be characterized. Furthermore, sensor data shall be calibrated to ensure measurement repeatability and the calibration statistics shall be capable of being monitored over the instrument lifetime. Instrument stability characterization is required by DOC in order to ensure that changes (stepwise or trends) over time in products or EDRs can be quantified with respect to any possible instrument performance changes. “Long term stability” is defined as the maximum excursion of the short-term average measured value of a parameter under identical conditions over the mission duration, i.e., life of the NPOESS program. The short-term average is the average of a sufficient number of successive measurements of the parameter under identical conditions such that the random error is negligible relative to the systematic error. In order to ensure the reliability of the mission, a USG user driven document on Calibration and Validation Requirements, companion to this IORD will be assembled. This document will undergo USG review and approval.

DOC’s climate prediction and monitoring mission depends on the ability of the NPOESS system to reliably (i) deliver the data within the bias limits specified by the accuracy requirements and (ii) quantify long-term stability to remove temporal variations in instrument bias. This will allow monitoring changes in observed physical parameters, as well as understanding natural vs. anthropogenic changes. The long-term stability values specified in the climate relevant EDRs are based on the estimated decadal trends of these environmental parameters. Meeting this requirement entails sensor design characterization and calibration, pre- and post-launch, successive sensor intercalibration and careful documentation of any algorithm changes in the product development.

EDRs are organized into Key, Atmospheric, Cloud, Earth Radiation Budget, Land, Ocean/Water, and Space Environmental parameters. Potential pre-planned product improvement EDRs are also listed. The Glossary Part II contains the definitions for parameter characteristics.

4.1.6.1 Key Environmental Performance Parameters (Listed alphabetically).

4.1.6.1.1 *Atmospheric Vertical Moisture Profile (*DOC/*DoD). Water vapor mixing ratio profile throughout the troposphere where moisture is normally measured via radiosonde. (Units: g kg^{-1}).

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	15 km at nadir	1 km
b. Vertical Reporting Interval		
1. Surface to 850 mb	20 mb	5 mb
2. 850 to 100 mb	50 mb	10 mb
c. Mapping Accuracy	5 km	0.5 km
d. Measurement Uncertainty (expressed as percent error of average mixing ratio in 2 km layers)		
Clear:		
1. Surface to 600 mb*	**Greater of 20 % or 0.2 g kg^{-1} (DoD: 25 %)**	10 %
2. 600 mb to 300 mb	Greater of 35 % or 0.1 g kg^{-1}	10 %
3. 300 mb to 100 mb	Greater of 35 % or 0.1 g kg^{-1}	10 %
Cloudy:		
4. Surface to 600 mb*	**Greater of 20 % or 0.2 g kg^{-1} (DoD: 25 %)**	10 %
5. 600 mb to 400 mb	Greater of 40 % or 0.1 gkg^{-1}	10 %
6. 400 mb to 100 mb	Greater of 40 % or 0.1 g kg^{-1}	10 %
e. Latency	156 minutes	15 minutes
f. Refresh	6 hours	3 hours
g. Long-Term Stability**	2%	1%

** Only applies to measurements from CrIS and ATMS.

4.1.6.1.2 *Atmospheric Vertical Temperature Profile (*DOC/*DoD). Sampling of temperature at stated intervals throughout the atmosphere.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size		
1. Clear, nadir	18.5 km	1 km
2. Clear, worst case	100 km	1 km
3. Cloudy, nadir	40 km	1 km
4. Cloudy, worst case	50 km	1 km

b. Vertical Reporting Interval		
1. Surface to 850 mb	20 mb	10 mb
2. 850 to 300 mb	50 mb	10 mb
3. 300 to 100 mb	25 mb	10 mb
4. 100 to 10 mb	20 mb	10 mb
5. 10 to 1 mb	2 mb	1 mb
6. 1 to 0.1 mb	0.2 mb	0.1 mb
7. 0.1 to 0.01 mb	0.02 mb	.01 mb
c. Mapping Accuracy	5 km	0.5 km
d. Measurement Uncertainty (expressed as error in layer average temperature)**		0.5 K
Clear:		
1. Surface to 300 mb*	**1.6 K per 1 km layer**	
2. 300 mb to 30 mb	1.5 K per 3 km layer	
3. 30 mb to 1 mb	1.5 K per 5 km layer	
4. 1 mb to 0.01 mb	3.5 K per 5 km layer	
Cloudy:		
5. Surface to 700 mb*	**2.5 K per 1 km layer**	
6. 700 mb to 300 mb	1.5 K per 1 km layer	
7. 300 mb to 30 mb	1.5 K per 3 km layer	
8. 30 mb to 1 mb	1.5 K per 5 km layer	
9. 1 mb to 0.01 mb	3.5 K per 5 km layer	
e. Latency	156 minutes	15 minutes
f. Refresh	6 hours	3 hours
g. Long-Term Stability***		
1. Trop. Mean	0.05 K	0.03 K
2. Strat. Mean	0.10 K	0.05 K

** Measurement Uncertainty as specified in 4.1.6.1.2 shall be referenced to the Cloudy Horizontal Cell Size thresholds and objectives as listed under 4.1.6.1.2-3 and 4.1.6.1.2-4.
*** Only applies to measurements from CrIS and ATMS.

4.1.6.1.3 * **<u>Global Sea Surface Winds (Speed and Direction) (DoD/DOC)</u>.** Measure of atmospheric wind speed/direction at the sea/atmosphere interface (10 meter height neutral stability winds) in clear sky and cloudy conditions, for integrated rainfall rates less than 2 mm hr^{-1} km^{-2} footprint.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	20 km	1 km
b. Mapping Uncertainty	5 km	1 km
c. Measurement Range	3 to 25 m s^{-1}, 0 to 360^o	1 to 50 m s^{-1}, 0 to 360^o
d. Measurement Accuracy		
1. Speed*	**Greater of 2 m s^{-1} or 10%**	Greater of 1 m s^{-1} or 10%
2. Direction**		
for wind speed > 5 m s^{-1}	20°	10^o
for wind speeds 3-5 m s^{-1}	25°	10^o

e. Refresh	6 hours	1 hour
f. Long Term Stability	0.5 m sec^{-1} $decade^{-1}$	-
g. Latency	90 minutes	15 minutes
h. Geographic Coverage	Global Ice-free Ocean	Global Ice-free Ocean

** Direction uncertainty is to be applied to the unique chosen ambiguity.

4.1.6.1.4 * **Imagery (DoD/DOC).** Specialized imagery at sufficient resolution to enable discernment of environmental phenomena (by either manual analysis or automated algorithms) within the visible, infrared, and passive microwave portions of the spectrum. Environmental phenomena range in size from cloud types and elements (as defined in AFI 15-111, Vol. I) to planetary scale (10^7 m) weather patterns. Imagery shall provide digital input, through single bands and/or combinations of band/channels, to remote sensing algorithms which produce other environmental measurements, although this does not replace the explicit requirement for retrieval of individual parameters described elsewhere in this document).

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size		
Nadir	**0.4 km**	0.1 km
Worst case	0.8 km	0.1 km
Night-time visual	2.6 km	0.65 km
All weather	40 km	20 km
b. Mapping Accuracy		
Nadir	1 km	
Worst case	3 km	0.5 km
All weather	5 km	3 km
c. Refresh (DoD) (for visible and IR bands)	**At any location: a) the average revisit time will be 4 hours or less and the maximum revisit time will be 6 hours or less; b) at least 75% of the revisit times will be 4 hours or less.**	1 hour
d. Latency	90 minutes	15 minutes

4.1.6.1.5 * Sea Surface Temperature (SST) (DOC/DoD). Sea Surface Temperature is defined as a highly precise measurement of the temperature of the surface layer (upper 1 meter) of ocean water. It has two major applications: 1) sea surface phenomenology, and 2) use in infrared cloud/no cloud decision for processed cloud data. The requirements below apply only under clear conditions (unless specified otherwise).

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size		
Nadir, clear	**1 km**	0.25 km
Worst case, clear	1.3 km	
All Weather	40 km	20 km
b. Mapping Accuracy		
Nadir, clear	1 km	0.1 km
Worst case, clear	1.3 km	
All Weather	5 km	3 km

c. Measurement Range	-2° to 40° C	-2° to 40° C
d. Measurement Precision		
Clear	0.2° C	0.1° C
All Weather	0.3 ° C	0.1 ° C
e. Measurement Uncertainty		
Clear	**0.5° C**	0.1° C
All Weather	1.0 ° C	0.5 ° C
f. Refresh	6 hours	3 hours
g. Long-Term Stability	0.1° C	.05° C
h. Latency	90 minutes	15 minutes
i. Geographic Coverage	Global Ocean	Global Ocean

4.1.6.1.6 *Soil Moisture (Surface) (*DoD/DOC). Soil moisture measurements are needed to derive trafficability information useful for support of the deployment of amphibious and ground forces. Moisture in the soil within the zone of aeration, including water vapor present in soil pores.

Systems Capabilities	Thresholds	Objectives
a. Sensing Depth*	**Surface (skin layer: -0.1 cm)**	Surface to –80 cm
b. Horizontal Cell Size		
1. Clear, nadir	1 km	0.5 km
2. Clear, worst case	4 km	2 km
3. Cloudy, nadir	40 km	2 km
4. Cloudy, worst case	50 km	2 km
c. Vertical Sampling Interval	Not Required	5 cm
d. Mapping Accuracy, clear, nadir	1 km	0.5 km
e. Mapping Accuracy, cloudy	5 km	1 km
f. Measurement Uncertainty**	Bare soil, in regions with known soil types: 10 % (low HCS); 20 % (high HCS - clear skies)	Surface: 1 % 80 cm column: 5 %
g. Measurement Range	0-100 %	0-100 %
h. Latency	90 minutes	30 minutes
i. Refresh	8 hours	3 hours

** Units are dimensionless and moisture refers to volumetric soil moisture.

4.1.6.2 Atmospheric Parameters.

4.1.6.2.1 Aerosol Optical Thickness (AOT) (DOC)/(DoD). Aerosol Optical Thickness for this EDR, is defined as the extinction (scattering + absorption) vertical optical thickness of modes 1 (~ 0.1 μm) and 2 (~ 1.0 μm) of the bimodal aerosol size distribution at multiple wavelengths within the 0.4 – 2.4 micron spectral range (# - applies to total column optical depth). The refresh requirement for the climate products is to provide observations from the satellite nadir-track of any satellite carrying the aerosol polarimeter. The requirements below apply only under clear conditions.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage	Surface to 30 km	Surface to 50 km
b. Horizontal Cell Size	10 km	1 km
c. Vertical Cell Size	Total column	
1. from 0 to 2 km		0.25 km
2. from 2 to 5 km		0.5 km
3. >5 km		1 km
d. Mapping Accuracy #	4 km	1 km
e. Measurement Range #		-
1. Operational	0 to 2	0 to 10
2. Climate	0 to 5	0 to 10
f. Measurement Precision #		
1. Operational	0.03	0.01
2. Climate	0.01 over ocean/0.03 over land	0.005 over ocean/0.02 over land
g. Measurement Accuracy		
1. Operational	0.03 over ocean	0.01
2. Climate		
over ocean	Greater of .02 or 7 %	Greater of .01 or 5 %
over land	Greater of 0.04 or 10 %	Greater of 0.03 or 7 %
h. Latency	90 minutes	15 minutes
i. Refresh		
1. Operational	6 hours	4 hours
2. Climate	N/A	N/A
j. Long Term Stability	0.01	0.005

4.1.6.2.2 Aerosol Particle Size (DOC). Measurement of the bimodal size distribution of the aerosol population in terms of the effective radius r_e and effective variance v_e of each mode. The effective radius is the ratio of the third moment of the aerosol size distribution to the second moment. The effective variance characterizes the width of the size distribution. The refresh requirement for the climate products is to provide observations from the satellite nadir-track of any satellite carrying the aerosol polarimeter. The requirements below apply only under clear conditions. (# -applies to the average column size distribution; ‡ - applies only to sub-satellite pixels).

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage	Surface to 30 km	Surface to 50 km
b. Horizontal Cell Size	10 km	1 km
c. Vertical Cell Size	Total column	
1. from 0 to 2 km		0.25 km
2. from 2 to 5 km		0.5 km
3. > 5 km		1 km
d. Mapping Accuracy #	4 km	1 km

e. Measurement Range		
1. Operational	-1 to +3	-2 to +4
2. Climate	0 to 5 µm for r_e 0 to 3 for v_e	0 to 10 µm for r_e 0 to 5 for v_e
f. Measurement Precision		
1. Operational	0.3	0.1
2. Climate	Greater of 0.05 µm or 10 % for r_e Greater of 0.1 or 40 % for v_e ‡	Greater of 0.05 µm or 5% for r_e Greater of 0.1 or 20 % for v_e
g. Measurement Accuracy		
1. Operational	0.3 over ocean	0.1
2. Climate	Greater of 0.1 µm or 10 % for r_e Greater of 0.3 or 50 % for v_e ‡	Greater of 0.05 µm or 5% for r_e Greater of 0.2 or 30 % for v_e
h. Refresh		
1. Operational	6 hours	4 hours
2. Climate	N/A	24 hours
i. Long Term Stability	Greater of 0.05 µm or 10 % for r_e Greater of 0.2 or 40 % for v_e ‡	Greater of 0.05 µm or 5 % for r_e Greater of 0.1 or 20 % for v_e

4.1.6.2.3 Aerosol Refractive Index, Single-Scattering albedo, and Shape (DOC) (applies only to sub-satellite pixels). Measurement of the real part of the refractive index *m* and the single-scattering albedo ϖ of each mode of the bimodal aerosol size distribution at multiple wavelengths within the 0.4-2.4 micron spectral range and determination whether aerosol particles are spherical or non-spherical. Non-sphericity is detected when the value $S = (Lmax\,Lmin^{-1} - 1) > 0.3$, where Lmax is the maximum length of the particle and Lmin is the minimum length of the particle. The value of S can be inferred form multi-angular measurements of the departure of scattered radiation from that expected from spherical aerosol particles. The refresh requirement for the climate products is to provide observations from the satellite nadir-track of any satellite carrying the aerosol polarimeter. The requirements below apply only under clear conditions (# - applies to the average column size distribution).

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage	Surface to 30 km	Surface to 50 km
b. Horizontal Cell Size	10 km	1 km
c. Vertical Cell Size	Total column	
1. from 0 to 2 km		0.25 km
2. from 2 to 5 km		0.5 km
3. > 5 km		1 km
d. Mapping Accuracy #	4 km	1 km
e. Measurement Range #	1.3 to 1.7 for *m* 0 to 1 for ϖ	1.3 to 1.8 for *m* 0 to 1 for ϖ
f. Measurement Precision #	0.01 for *m* 0.02 for ϖ	0.005 for *m* 0.01 for ϖ
g. Measurement Accuracy #	0.02 for *m* 0.03 for ϖ	0.01 for *m* 0.01 for ϖ

h. Refresh	N/A	N/A
i. Long Term Stability	0.01 for *m* 0.02 for ϖ	0.005 for *m* 0.01 for ϖ

4.1.6.2.4 Ozone Total Column/Profile (DOC/DoD). Measurement of ozone concentration within a specified volume. (TH is Tropopause Height or 8 km, whichever is greater as determined by ancillary data.)

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size		
1. Total Column	50 km at nadir	50 km worst case
2. Profile	250 km	250 km
b. Vertical Cell Size		
1. 0 to TH	N/A	3 km
2. TH to 25 km	5 km	1 km
3. 25 to 60 km	5 km	3 km
c. Mapping Accuracy		
1. Total Column, at nadir	5 km	5 km
2. Profile	25 km	25 km
d. Measurement Range		
1. Total Column	0.05 to 0.65 atm-cm	0.05 to 0.65 atm-cm
2. Profile		
a) 0 to TH	N/A	0.01 to 3 ppmv
b) TH to 60 km	0.1 to 15 ppmv	0.1 to 15 ppmv
e. Measurement Precision		
1. Total Column	0.003 atm-cm + 0.5 % of measured ozone	0.001 atm-cm
2. Profile		
a) 0 to TH	N/A	10 %
b) TH to 15 km	Greater of 10 % or 0.1 ppmv	3 %
c) 15 to 50 km	Greater of 3 % or 0.05 ppmv	1 %
d) 50 to 60 km	Greater of 10% or 0.1 ppmv	3 %
f. Measurement Accuracy		
1. Total Column	0.015 atm-cm	0.005 atm-cm
2. Profile		
a) 0 to TH	N/A	10 %
b) TH to 15 km	Greater of 20 % or .1 ppmv	10 %
c) 15 to 60 km	Greater of 10 % or .1 ppmv	5 %
g. Latency	120 minutes	15 minutes
h. Refresh		
1. Total Column	24 hours	24 hours
2. Profile	7 days	24 hours
i. Long Term Stability		
1. Total Column	1 % over 7 years	0.5 % over 7 years
2. Profile	2 % over 7 years	1 % over 7 years

4.1.6.2.5 Precipitable Water/Integrated Water Vapor (DOC/DoD). Total atmospheric water vapor contained in a vertical column of unit cross-sectional area between any two specified levels, including the total atmospheric column. The requirements below apply under both clear and cloudy conditions. Units are millimeters of condensed vapor.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage	Surface to Top of Atmosphere (TOA)	
b. Horizontal Cell Size	25 km	1 km
c. Mapping Accuracy	5 km	0.1 km
d. Measurement Range	0 to 75 mm	0 to 100 mm
e. Measurement Precision	1 mm	1 mm
f. Measurement Accuracy	greater of 2 mm or 10 %	Greater of 1 mm or 4 %
g. Latency	90 minutes	15 minutes
h. Refresh	8 hours	3 hours
i. Long Term Stability	greater of 1.0 mm or 4 %	greater of 0.2 mm or 1 %

4.1.6.2.6 Precipitation Type/Rate (DoD/DOC). Precipitation rate and identification by type as rain or ice. The requirements below apply under all weather conditions.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	15 km	0.1 km
b. Mapping Accuracy	5 km	0.1 km
c. Measurement Range	0 to 50 mm hr^{-1}	
d. Measurement Precision	1 mm hr^{-1}	1 mm hr^{-1}
e. Measurement Accuracy	2 mm hr^{-1}	2 mm hr^{-1}
f. Latency	90 minutes	15 minutes
g. Refresh	8 hours	1 hour
h. Long Term Stability	1.0 mm/hr or 10 %	0.1 mm/hr or 1 %

4.1.6.2.7 Pressure (Surface/Profile) (DoD). Measurement of pressure at surface and profile. The requirements below apply under both clear and cloudy conditions.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage	Surface to 30 km	Surface to 30 km
b. Horizontal Cell Size	25 km	5 km
c. Vertical Cell Size		
1. 0 to 2 km	1 km	0.25 km
2. 2 to 5 km	1 km	0.5 km
3. > 5 km	1 km	1 km
d. Mapping Accuracy	7 km	1 km
e. Measurement Range	10 to 1050 mb	10 to 1050 mb
f. Measurement Precision	4 mb	2 mb
g. Measurement Accuracy		
1. 0 to 10 km	Greater of 1 % or 10 mb	0.5 %
2. 10 to 30 km	Greater of 1 % or 10 mb	0.5 %
h. Latency	156 minutes	15 minutes
i. Refresh	12 hours	1 hour

4.1.6.2.8 Suspended Matter (DoD/DOC). As a threshold, the required content of this EDR is to report the presence of suspended matter such as dust, sand, volcanic ash, SO_2, or smoke at any altitude. The objective is to report the presence of suspended matter in 0.2 km thick layers of the atmosphere, including sea salt and radioactive materials. The requirements below apply only under clear, daytime conditions.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	3 km	1 km
b. Vertical Cell Size	Total Column	0.2 km
c. Mapping Uncertainty	3 km	0.1 km
d. Measurement Range		
1. Detect suspended matter	dust, sand, ash, SO_2	dust, sand, ash, SO_2, sea salt
2. Radioactive/smoke plumes	N/A	0 to 100 $\mu g\ m^{-3}$ (smoke)
e. Latency	90 minutes	15 minutes
f. Refresh	12 hours	3 hours

4.1.6.2.9 Total Water Content (DoD). Measure of moisture in a given volume of the atmosphere. The requirements below apply under both clear and cloudy conditions. Total water content is defined as the water vapor, liquid water, and cloud ice liquid equivalent in specified segments of a vertical column of the atmosphere.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	20 km	10 km
b. Vertical Cell Size	3 km	1 km
c. Mapping Accuracy	7 km	7 km
d. Measurement Uncertainty		
1. Point Measurement	2 $kg\ m^{-2}$	
2. Global Average	1 $kg\ m^{-2}$	
e. Latency	90 minutes	15 minutes
f. Refresh	8 hours	3 hours

4.1.6.3 Cloud Parameters (DoD/DOC). Cloud data are required by both DoD and DOC. The specific types of cloud data required are broken out in the following subparagraphs.

4.1.6.3.1 Cloud Base Height (DOC/DoD). Height above ground level where cloud bases occur, from surface to 15 km (threshold), 30 km (objective).

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	25 km	1 km
b. Vertical Reporting Interval	Base of up to four layers	Base of all distinct cloud layers
c. Mapping Accuracy	2 km	1 km
d. Measurement Uncertainty	2 km	0.25 km
e. Latency	90 minutes	15 minutes
f. Refresh	6 hours	4 hours
g. Long Term Stability	2.0 km	0.1 km

4.1.6.3.2 Cloud Cover/Layers (DoD/DOC). Cloud cover is the fraction of a given area that is overlaid in the local normal direction by clouds; it is the portion of the earth's horizontal surface that is masked by the vertical projection of clouds. It needs to be known at separate, distinct levels.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	25 km	1 km
b. Vertical Reporting Interval	4 layers	0.1 km
c. Mapping Uncertainty	4 km	1 km
d. Measurement Range	0 to 1.0	0 to 1.0
e. Measurement Precision	15 %	2.5 %
f. Measurement Accuracy	10 %	5 %
g. Latency	90 minutes	15 minutes
h. Refresh	6 hours	4 hours
i. Long Term Stability	0.1	0.002

4.1.6.3.3 Cloud Particle Size Distribution (DOC)/(DoD). The effective radius r_e and effective variance v_e of a single mode particle size distribution. The effective radius is the ratio of the third moment of the size distribution to the second moment. The effective variance characterizes the width of the size distribution (‡ - applies only to sub-satellite pixels). The refresh requirement for the climate products is to provide observations from the satellite nadir-track of any satellite carrying the aerosol polarimeter.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	15 km	5 km
b. Vertical Reporting Interval	1 km	0.3 km
c. Mapping Uncertainty	4 km	1 km
d. Measurement Range	0 to50 µm for r_e 0 to 2 for v_e	0 to 80 µm for r_e 0 to 3 for v_e
e. Measurement Precision	greater of 0.5 µm or 5 % for r_e greater of 0.04 or 40 % for v_e ‡	greater of 0.3 µm or 3 % for r_e greater of 0.03 or 30 % for v_e
f. Measurement Accuracy	greater of 1 µm or 10 % for r_e greater of 0.05 or 50 % for v_e ‡	greater of 0.5 µm or 5 % for r_e greater of 0.04 or 40 % for v_e
g. Refresh	N/A	N/A
h. Long Term Stability	greater of 0.5 µm or 5 % for r_e greater of 0.04 or 40 % for v_e ‡	greater of 0.3 µm or 3 % for r_e greater of 0.03 or 30 % for v_e

The range has been increased to reflect the fact that ice crystals should also be subject to this computation, and their effective radii are likely to be as large as 100 microns.

4.1.6.3.4 Cloud Effective Particle Size (DOC/DoD). Area-averaged measure of cloud particle size, derived from imagery. The effective radius is the ratio of the third moment of the drop size distribution to the second moment.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	50 km	1 km
b. Vertical Reporting Interval	1 km	0.3 km

c. Mapping Uncertainty	2 km	1 km
d. Measurement Range	0 to 50 μm	
e. Measurement Precision	greater of 5 % or 2 μm	2 %
f. Measurement Accuracy	greater of 10 % or 4 μm	greater of 5 % or 2 μm
g. Latency	90 minutes	15 minutes
h. Refresh	6 hours	4 hours
i. Long Term Stability	2 %	1 %

4.1.6.3.5 Cloud Ice Water Path (DOC). A measure of the equivalent water mass of the ice particles in a unit vertical column through the cloud. Measured information is dependent on the number of particles, their sizes, and their densities.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage	Surface to 20 km	Surface to 20 km
b. Horizontal Cell Size	50 km	10 km
c. Vertical Reporting Interval	Total column	0.3 km
d. Mapping Uncertainty	5 km	1 km
e. Measurement Range	0.01 to 1 mm	0 to 2 mm
f. Measurement Precision	Greater of 0.05 mm or 10 %	Greater of 0.02 mm or 4 %
g. Measurement Accuracy	Greater of 0.1 mm or 25 %	Greater of 0.05 mm or 10 %
h. Latency	156 minutes	15 minutes
i. Refresh	8 hours	3 hours
j. Long Term Stability	2 %	1 %

4.1.6.3.6 Cloud Liquid Water (DOC/DoD). Measurement of water equivalent within non-precipitating clouds.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	20 km	1 km
b. Vertical Reporting Interval	Total Column	0.3 km
c. Mapping Uncertainty	5 km	1 km
d. Measurement Uncertainty	±0.25 mm over ocean, ±0.5 mm over land	0.01 mm
e. Latency	90 minutes	15 minutes
f. Refresh	8 hours	4 hours
g. Range	0.005 – 1 mm	0-2 mm
h. Long Term Stability	greater of .05 mm or 10 %	greater of .01 mm or 1 %

4.1.6.3.7 Cloud Optical Thickness (DOC). Cloud optical thickness is defined as the extinction (scattering + absorption) vertical optical thickness of all cloud layers in a vertical column of the atmosphere.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	50 km	10 km
b. Vertical Sampling Interval	Total Column	4 Layers
c. Mapping Uncertainty	4 km	1 km
d. Measurement Precision	Greater of 5 % or 0.025 optical depth	2 %

e. Measurement Accuracy	Greater of 10 % or 0.05 optical depth	5 %
f. Latency	90 minutes	15 minutes
g. Refresh	8 hours	3 hours
h. Long Term Stability	2 %	1 %

4.1.6.3.8 Cloud Top Height (DOC/DoD). Measurement of cloud top height of up to four cloud layers as a threshold, of all layers as an objective.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	25 km	1 km
b. Vertical Reporting Interval	Tops of up to four layers	Tops of all distinct cloud layers
c. Mapping Uncertainty	4 km	1 km
d. Measurement Precision	0.3 km	0.15 km
e. Measurement Accuracy		
1. Optically thick	1.0 km	0.3 km
2. Optically thin	2 km	0.3 km
f. Latency	90 minutes	15 minutes
g. Refresh	6 hours	4 hours
h. Long Term Stability	0.2 km	0.1 km

4.1.6.3.9 Cloud Top Pressure (DOC). Derived atmospheric pressure at cloud tops for optically thick clouds. The highest cloud layer is a threshold; all layers is an objective.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	25 km	1 km
b. Mapping Uncertainty	2 km	1 km
c. Measurement Precision		
1. Surface to 3 km	50 mb	10 mb
2. 3 to 7 km	38 mb	7 mb
3. > 7 km	25 mb	5 mb
d. Measurement Accuracy		
1. Surface to 3 km	100 mb	30 mb
2. 3 to 7 km:	75 mb	22 mb
3. > 7 km	50 mb	15 mb
e. Latency	90 minutes	15 minutes
f. Refresh	6 hours	4 hours
g. Long Term Stability		
1. Surface to 3 km	10 mb	3 mb
2. 3 to 7 km	7 mb	2 mb
3. > 7 km	5 mb	1 mb

4.1.6.3.10 Cloud Top Temperature (DOC/DoD). Measurement of temperature at the top of the highest cloud layer as a threshold, at the top of all cloud layers as an objective.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	25 km	1 km
b. Mapping Uncertainty	4 km	1 km

c. Measurement Precision	1.5 K	0.5 K
d. Measurement Accuracy		
1. Optically thick	3 K	1.5 K
2. Optically thin	6 K	2 K
e. Latency	90 minutes	15 minutes
f. Refresh	6 hours	4 hours
g. Long Term Stability	1 K	0.1 K

4.1.6.4 Earth Radiation Budget Parameters. All requirements for Earth Radiation Budget EDRs below apply only under both clear and cloudy conditions except for the Surface Albedo.

4.1.6.4.1 Albedo (Surface) (DOC/DoD). Measurement of the ratio of the amount of spectrum electromagnetic radiation reflected in the 0.4 – 4.0 micron band reflected by the Earth to the amount incident upon it. This EDR is required during daytime only and under clear conditions only.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	4 km	0.5 km
b. Mapping Uncertainty	4 km	1 km
c. Measurement Range	0 to 1.0	0 to 1.0
d. Measurement Precision	.02 (albedo units)	.02
e. Measurement Accuracy	.03 (albedo units)	.0125
f. Latency	150 minutes	60 minutes
g. Refresh	24 hours	4 hours
h. Long Term Stability	.02 (albedo units)	.01

4.1.6.4.2 Downward Longwave Radiation (DLR) (Surface) (DOC). DLR at the surface is defined as radiation from 5.0 to 100 µm. This is an instantaneous, not a time-averaged, measurement.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	25 km at nadir	10 km at nadir
b. Mapping Uncertainty	5 km at nadir	1 km at nadir
c. Measurement Range	0 to 500 W m^{-2}	0 to 500 W m^{-2}
d. Measurement Precision	20 W m^{-2}	6 W m^{-2}
e. Measurement Accuracy	10 W m^{-2}	3 W m^{-2}
f. Latency	150 minutes	60 minutes
g. Refresh	14 hours	6 hours
h. Long Term Stability	0.5 W m^{-2}	0.2 W m^{-2}

4.1.6.4.3 Downward Shortwave Radiation (Surface) (DOC). Downward shortwave radiation (surface) is defined as the irradiance at wavelengths less than 4 µm incident downward at the surface of the earth. This is an instantaneous, not a time-averaged, measurement.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	25 km at nadir	10 km at nadir
b. Mapping Uncertainty	5 km at nadir	1 km at nadir
c. Measurement Range	0 to 1400 W m^{-2}	0 to 1400 W m^{-2}
d. Measurement Precision	20 W m^{-2}	6 W m^{-2}

e. Measurement Accuracy	10 W m^{-2}	3 W m^{-2}
f. Latency	150 minutes	60 minutes
g. Refresh	24 hours	12 hours
h. Long Term Stability	0.5 W m^{-2}	0.2 W m^{-2}

4.1.6.4.4 Net Solar Radiation at the top of the Atmosphere (DOC). Incident minus reflected solar radiation (Top of the atmosphere). This is an instantaneous, not a time-averaged, measurement.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	25 km at nadir	10 km at nadir
b. Mapping Uncertainty	5 km at nadir	2 km at nadir
c. Measurement Range	0 to 1400 W m^{-2}	0 to 1400 W m^{-2}
d. Measurement Precision	15 W m^{-2}	5 W m^{-2}
e. Measurement Accuracy	3 W m^{-2}	1 W m^{-2}
f. Latency	150 minutes	60 minutes
g. Refresh	24 hours	12 hours
h. Long Term Stability	0.2 W m^{-2}	0.1 W m^{-2}

4.1.6.4.5 Solar Irradiance (DOC). Incident radiation measurements (total and spectral at the top of the Atmosphere).

Systems Capabilities	Thresholds	Objectives
a. Measurement Range		
1. Total	1310 to 1420 W m^{-2}	1310 to 1420 W m^{-2}
2. Spectral (0.2-2μm)	0-10 W m^{-2} nm^{-1}	0-10 W m^{-2} nm^{-1}
b. Long Term Stability		
1. Total	0.002 % yr^{-1}	0.0005 % yr^{-1}
2. Spectral (0.2-2μm)		
a. $\lambda < 600$ nm	0.02 % yr^{-1}	0.01 % yr^{-1}
b. $\lambda > 600$ nm	0.01 % yr^{-1}	0.01 % yr^{-1}
c. Measurement Precision		
1. Total	0.002 % yr^{-1}	0.0005 % yr^{-1}
2. Spectral (0.2-2μm)	0.02 %yr^{-1}	0.01 % yr^{-1}
d. Measurement Accuracy		
1. Total	1.5 W m^{-2} (0.1 %)	0.15 W m^{-2} (0.01 %)
2. Spectral (0.2-2μm)	1 %	0.1 %
e. Refresh	20 minutes of viewing sun each orbit, 1 satellite	20 minutes of viewing sun each orbit, 3 satellites
f. Spectral Resolution		
1. $\lambda < 280$ nm	1 nm	0.1 nm
2. 280 nm $< \lambda <$ 400 nm	5 nm	0.1 nm
3. $\lambda > 400$ nm	35 nm	1.0 nm

4.1.6.4.6 Outgoing Longwave Radiation (Top of Atmosphere(TOA)) (DOC). Outgoing longwave radiation (5.0 to 100 µm). This is an instantaneous, not a time-averaged, measurement.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	25 km at nadir	10 km at nadir
b. Mapping Uncertainty	5 km at nadir	2 km at nadir
c. Measurement Range	0 to 500 W m^{-2}	0 to 500 W m^{-2}
d. Measurement Precision	12 W m^{-2}	5 W m^{-2}
e. Measurement Accuracy	5 W m^{-2}	2 W m^{-2}
f. Latency	150 minutes	60 minutes
g. Refresh	12 hours (once/daytime & once/nighttime)	4 hours
h. Long Term Stability	0.2 W m^{-2}	0.1 W m^{-2}

4.1.6.5 Land Parameters.

4.1.6.5.1 Land Surface Temperature (DoD/DOC). Land surface temperature is defined as the skin temperature of the uppermost layer of the land surface. It has two major applications: 1) characterization of backgrounds for electro-optical systems; and 2) use in infrared cloud/no cloud decision for processed cloud data. This EDR is required under clear conditions only.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	4 km	1 km
b. Mapping Uncertainty	4 km	1 km
c. Measurement Range	213 to 343 K	183 to 343 K
d. Measurement Precision	0.5 K	0.025 K
e. Measurement Accuracy	2.5 K	1 K
f. Latency	90 minutes	15 minutes
g. Refresh	6 hours	3 hours

4.1.6.5.2 Vegetation Index (DOC/DoD). Measure of biomass greenness in NDVI units. This EDR is required under clear conditions only.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	4 km	1 km
b. Mapping Uncertainty	4 km	1 km
c. Measurement Range	-1 to +1	-1 to +1
d. Measurement Precision	0.04 NDVI units	0.02 NDVI units
e. Measurement Accuracy	0.05 NDVI units	0.03 NDVI units
f. Latency	90 minutes	15 minutes
g. Refresh	24 hours	24 hours
h. Long Term Stability	0.04 NDVI units	0.04 NDVI units

4.1.6.5.3 Snow Cover/Depth (DoD/DOC). Horizontal and vertical extent of snow cover.

Systems Capabilities	Thresholds	Objectives
a. Sensing Depth	0 to 40 cm	1 m
b. Horizontal Cell Size		
1. Clear	1.3 km	1 km

2. Cloudy and/or nighttime	12.5 km	1 km
c. Snow Depth Ranges	>0 cm (any snow depth)	> 8 cm > 15 cm > 30 cm > 51 cm > 76 cm
d. Mapping Uncertainty		
1. Clear	3 km	1 km
2. Cloudy	7 km	1 km
e. Measurement Uncertainty		
1. Clear	10 % (snow/no snow)	10 % for snow depth
2. Cloudy	20 % (snow/no snow)	
f. Latency	90 minutes	15 minutes
g. Refresh	12 hours	3 hours
h. Long Term Stability	10 %	1 % continental

4.1.6.5.4 Surface Type (DoD). Predominant vegetation type in a given area, coupled with type of soil. The 17 types to be measured are in accordance with standard International Geosphere Biosphere Program (IGBP) classes. Also used to support decision aids for precision guided munitions. The requirements below apply under both clear and cloudy conditions.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	20 km	0.25 km
b. Mapping Uncertainty	5 km	1 km
c. Measurement Range	17 IGBP classes	17 IGBP classes
d. Measurement Precision	10 %	0.1 %
e. Measurement Accuracy	70 % correct for 17 types	2 %
f. Latency	90 minutes	15 minutes
g. Refresh	24 hours	3 hours

4.1.6.6 Ocean/Water Parameters

4.1.6.6.1 Surface Currents (DOC). Deleted.

4.1.6.6.2 Sea Surface Temperature (SST) Gradients(DOC/DoD). Deleted.

4.1.6.6.3 Net Heat Flux (DoD). Refers to net surface flux over oceans (including ice covered). The components of heat flux are longwave/shortwave radiation, latent heat flux, and sensible heat flux. This EDR is required under clear conditions only.

Systems Capabilities	Thresholds	Objectives
a. Sensing Depth	N/A	N/A
b. Horizontal Cell Size	20 km	5 km
c. Mapping Uncertainty	7 km	
d. Measurement Range	0 to 1000 W m^{-2}	0 to 2000 W m^{-2}
e. Measurement Precision	5 W m^{-2}	1 W m^{-2}
f. Measurement Accuracy	10 W m^{-2}	1 W m^{-2}
g. Refresh	6 hours	3 hours

h. Latency	24 hours	6 hours
i. Geographic Coverage	Global Oceans	Global Oceans

4.1.6.6.4 Sea Ice Characterization (DOC/DoD). Sea ice properties derived from all-weather imagery.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage	Ice Surface	Ice Surface
b. Horizontal Cell Size	20 km	0.05 km
c. Mapping Uncertainty	5 km	0.05 km
d. Measurement Range		
1. Ice Concentration	1/10 to 10/10	0/10 to 10/10
2. Ice Age	Ice free, multiyear, all other ice	Ice Free, Nilas, GreyWhite, Grey, White, First Year Medium, First Year Thick, Second Year, and Multiyear; Smooth and Deformed Ice
e. Measurement Uncertainty		
1. Ice Concentration	1/10 (i.e., 10 %)	5 %
2. Ice Age (probability of correct typing)	70 %	90 %
f. Refresh	24 hours	6 hours
g. Long-Term Stability		
1. Ice Concentration	1 %	
h. Latency	8 hrs	15 minutes
i. Geographic Coverage	All ice-covered regions of the global ocean	Same as Threshold

4.1.6.6.5 Ice Surface Temperature (DOC/DoD). Temperature at the ice surface. This EDR is required under clear conditions only.

Systems Capabilities	Thresholds	Objectives
a. Sensing Depth	Ice Surface	Ice Surface
b. Horizontal Cell Size	1.0 km (nadir) 1.6 km (worst case)	0.1 km
c. Mapping Uncertainty	1.0 km (nadir), 1.6 km (worst case)	0.1 km
d. Measurement Range	213-275 K	213-293 K (2m above ice)
e. Measurement Uncertainty	1 K	
f. Refresh	24 hours	12 hours
g. Latency	90 min	15 min
h. Geographic Coverage	Ice-covered oceans & navigable waters associated with the Great Lakes & Chesapeake & Delaware Bays.	All ice-covered waters

4.1.6.6.6 Ocean Color (DoD/DOC). Ocean color is defined as the spectrum of water-leaving radiances (L_w), i.e. the portion of visible – near infrared light that is reflected out of the water column, excluding light reflected at the surface. All geophysical quantities of interest, e.g. the concentration of the phytoplankton pigment chlorophyll *a* (chlorophyll-*a*) and the inherent optical properties of absorption and scattering of surface waters (ocean optical properties), are derived from these L_w values. Water-leaving radiances are measured in W m^{-2} μm^{-1} sr^{-1}. Ocean optical properties, absorption and scattering, are estimated at each measured visible wavelength, and have units of inverse meters (m^{-1}) while Chlorophyll *a* is measured in mg m^{-3}. This EDR is required for clear daytime conditions only. Note: Science Quality requirements will be achieved using post-processing techniques (i.e., additional ancillary data) outside the IDP Segment.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size		
Nadir	0.75 km	
Worst case	1.6 km	0.1 km
b. Mapping Uncertainty		
Nadir	0.75 km	
Worst case	1.6 km	0.1 km
c. Measurement Range		
1. Ocean Color	0.10 – 10 W m^{-2} μm^{-1} sr^{-1}	0. 05-10 W m^{-2} μm^{-1} sr^{-1}
2. Optical Properties.		
a) Absorption	0.01- 10 m^{-l}	0.005 – 20 m^{-}
b) Scattering	0.01 – 50 m^{-l}	0.005 – 75 m^{-l}
c) Chlorophyll fluorescence	N/A	Detectable signal in waters with chlorophyll from 0.1 to 50 mg m^{-3} at 1 km resolution
3. Chlorophyll	0.01 to 50 mg m^{-3}	0.001-100 mg m^{-3}
d. Measurement Precision		
1. Ocean Color		
a) Operational	5 %	2 %
b) Science Quality	2 %	1 %
2. Optical Properties		
a) Operational	20 %	20 %
b) Science Quality	20 %	10 %
3. Chlorophyll		
a)Operational	20 %	10 %
b) Science Quality	10 %	5 %
e. Measurement Accuracy		
1. Ocean Color		
a) Operational	10 %	5 %
b) Science Quality	5 %	3 %
2. Optical Properties		
a) Operational	40 %	30 %
b) Science Quality	30 %	20 %
3. Chlorophyll		
a) Operational	40 %	20 %
b) Science Quality	30 %	10 %

f. Refresh	24 hours	12 hours
g. Long-Term Stability		
At the wavelength of Max Chlorophyll absorption	0.50 W m^{-2} μm^{-1} sr^{-1}	0.250 W m^{-2} μm^{-1} sr^{-1}
At the wavelength of Min Chlorophyll absorption	0.25 W m^{-2} μm^{-1} sr^{-1}	0.125 W m^{-2} μm^{-1} sr^{-1}
At near IR wavelength used for Atmospheric correction	0.080 W m^{-2} μm^{-1} sr^{-1}	0.040 W m^{-2} μm^{-1} sr^{-1}
h. Latency		
1. Operational	180 minutes	60 minutes
2. Science Quality	48 hours	24 hours

4.1.6.6.7 Sea Surface Height/Topography (DOC)/(DoD). Sea surface height is the topography of the ocean surface with respect to the Earth's reference ellipsoid in a well-maintained terrestrial reference frame. Its variability is associated with mesoscale, basin scale, and global scale (DOC only) ocean phenomena. The requirements below apply under both clear and cloudy conditions. Note: following terminology is altimeter-specific. See Glossary Part II for terms and definitions specific to Sea Surface Height..

Systems Capabilities	Thresholds	Objectives
a. Horizontal Resolution		
1. Satellite Nadir Resolution	15 km	2 km
2. Horizontal Reporting Interval	1 km	0.2 km
3. Closest Point to Shore	10 km	3 km
b. Measurement Precision	3 cm	2 cm
c. Measurement Accuracy		
1. Mesoscale	6 cm	4 cm
2. Basin Scale	5 cm	3 cm
3. Global Scale	4 cm	2 cm
d. Exact Repeat Period	20 days	10 days
e. Equatorial Track Spacing	≤ 165 km	≤ 50 km
f. Latency		
1. Mesoscale	24 hr	3 hr
2. Basin Scale	3 days	2 days
3. Global Scale	3 months	2 months
g. Geographic Coverage	66S to 66N latitude	85S to 85N
h. Long Term Stability (after calibration)	1 mm yr^{-1}	0.5 mm yr^{-1}

4.1.6.6.8 Ocean Wave Characteristics – Significant Wave Height (DoD)/(DOC). The height of ocean waves expressed as significant wave height (i.e., the average height of the highest one-third of the waves in a horizontal cell size). The requirements below apply under both clear and cloudy conditions. Note: Refresh requirement is to provide observations along the satellite nadir-track of any satellite carrying an altimeter.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size		
Nadir, along track	2.5-20 km (Seastate Dependent)	2.5 km
b. Mapping Uncertainty	2 km	0.25 km
c. Measurement Range (Height)	0.1 to 30 m	0.0 to 30 m
d. Measurement Precision (Height)	0.2 m or 10 %, whichever is greater	0.1 m or 10 %, whichever is greater
e. Measurement Accuracy (Height)	0.2 m	0.2 m
f. Refresh	As Available from Altimetry	As Available from Altimetry
g. Long-Term Stability	N/A	N/A
h. Latency	120 minutes	15 minutes
i. Geographic Coverage	Global ice-free ocean and Great Lakes	Global ice-free ocean and Great Lakes

4.1.6.6.9 Global Sea Surface Wind Stress (DOC/DoD). The frictional stress of the wind acting on the sea surface, causing it to move as a wind-drift current, and causing the formation of waves. The requirements below apply under both clear and cloudy conditions.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	20 km	1 km
b. Mapping Uncertainty	5 km	1 km
c. Measurement Range	0 to 2 N m^{-2}	0 to 10 N m^{-2}
d. Measurement Precision	0.02 N m^{-2}	0.01 N m^{-2}
e. Measurement Accuracy	0.02 N m-^{2}	0.01 N m^{-2}
f. Refresh	8 hours	1 hour
g. Long-Term Stability	N/A	N/A
h. Latency	90 minutes	15 minutes
i. Geographic Coverage	Global Ocean	Global Ocean

4.1.6.7 Space Environmental Parameters

4.1.6.7.1 Auroral Boundary (DoD/DOC). Location of the equatorial boundary of the auroral zone.

Systems Capabilities	Thresholds	Objectives
a. Measurement Uncertainty	100 km	10 km
b. Latency	90 minutes	15 minutes

4.1.6.7.2 Auroral Energy Deposition (DoD/DOC). Measure of the heat flux to the ionosphere from auroral particle precipitation.

Systems Capabilities	Thresholds	Objectives
a. Measurement Range		
1. Energy Flux	10^{-4} to 1 W m^{-2}	$5x10^{-5}$ to 1 W m^{-2}
2. Mean Energy	100 eV to 20 keV	30 eV to 30 keV
b. Measurement Uncertainty	greater of 10^{-4} W m^{-2} or 20 %	greater of $5x10^{-5}$ W m^{-2} or 10 %
c. Latency	90 minutes	15 minutes

4.1.6.7.3 Auroral Imagery (DoD/DOC). Imagery used to specify the degree of auroral activity at locations within the auroral zones.

Systems Capabilities	Thresholds	Objectives
a. Measurement Range	Moderate to very active aurora	Quiet to very active aurora
b. Measurement Uncertainty	10 %	5 %
c. Horizontal Cell Size	100 km	10 km
d. Latency	90 minutes	15 minutes

4.1.6.7.4 Electric Field (DoD/DOC). The ambient, quasi-DC, electric in the immediate external environment of the satellite wherein any charged particle would experience an electrical force.

Systems Capabilities	Thresholds	Objectives
a. Measurement Range	0 to $\pm$150 mV m^{-1}	0 to $\pm$250 mV m^{-1}
b. Measurement Precision	2 mV m^{-1}	0.1 mV m^{-1}
c. Measurement Uncertainty	3 mV m^{-1}	0.1 mV m^{-1}
d. Latency	90 minutes	15 minutes

4.1.6.7.5 Electron Density Profile (DoD/DOC). Specifies the ionosphere by measuring Electron Density Profiles (EDPs), Total Electron Content (TEC), and identify features of the E and F_2 regions. Specification of the ion composition within the ionosphere is an Objective for this EDR. (Note: 1 TEC = 10^{16} m^{-2}.)

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size		
1. 0 to 30^o Lat	100 km	10 km
2. 30 to 50^o Lat	500 km	250 km
3. 50 to 90^o Lat	50 km	10 km
b. Vertical Cell Size		
1. 90-500 km	10 km	3 km
2. > 500 km	20 km	5 km
c. Vertical Coverage	90 km to Satellite Altitude	90 to 1600 km
d. Measurement Range		
1. Density, n_e	2.5×10^4 to 10^7 cm^{-3}	10^4 to 10^7 cm^{-3}
2. VTEC	3 to 200 TEC units	1 to 200 TEC units
3. Ion composition		O_2^+, NO^+, O^+, H^+, He^+
e. Measurement Uncertainty		
1. Density, n_e	Greater of 10^5 cm^{-3} or 30 %	Greater of $10^4 cm^{-3}$ or 5 %
2. TEC, vertical	Greater of 3 TECU or 30 %	Greater of 1 TECU or 30 %
3. Features:		
i. h_mF_2	20 km	5 km
ii. n_mF_2	20 %	10 %
iii. n_mE	20 %	5 %
4. Composition Discrimination		5 % of local density, n_e
f. Latency	90 minutes	15 minutes

4.1.6.7.6 Geomagnetic Field (DoD/DOC). Measurements of the Earth's vector magnetic field.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Reporting Interval	1.0 km	0.1 km
b. Horizontal Cell Size	100 m	100 m
c. Measurement Range	0 to $\pm$60,000 nT	0 to $\pm$60,000 nT
d. Measurement Precision	30 nT (per axis)	30 nT (per axis)
e. Measurement Accuracy	5 nT (per axis)	2 nT (per axis)
f. Latency	90 minutes	15 minutes

4.1.6.7.7 *In-situ* Plasma Fluctuations (DoD/DOC). Measurement of ionospheric density variations which are responsible for radiowave scintillation.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Reporting Interval	100 km	50 km
b. Measurement Range		
1. Spectral Index	1 to 5	1 to 5
2. $\Delta n/n$	10^{-2} to 1.0	10^{-2} to 1.0
c. Measurement Uncertainty		
1. I*n-situ* Density	Greater of 20 % or $5 \times 10^4 cm^{-3}$	Greater of 5 % or $2 \times 10^2 cm^{-3}$
d. Latency	90 minutes	15 minutes

4.1.6.7.8 *In-situ* Plasma Temperature - T_e & T_i (DoD/DOC). Plasma temperatures.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Reporting Interval	100 km	10 km
b. Measurement Range	500 to 10,000 K	500 to 10,000 K
c. Measurement Uncertainty	10 %	5 %
d. Latency	90 minutes	15 minutes

4.1.6.7.9 Ionospheric Scintillation (DoD/DOC). The fluctuation of both amplitude and phase of an electromagnetic frequency signal caused by variations in electron density along the transmission path.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	100 km	25 km
b. Measurement Range		
1. Amplitude Index (S4)	0.1 to 1.5	0.1 to 1.5
2. Phase Index (σ_ϕ)	0.1 to 20 radians	0.1 to 20 radians
c. Measurement Uncertainty		
1. Amplitude Index (S4)	0.1	0.1
2. Phase Index (σ_ϕ)	0.1 radians	0.1 radians
d. Latency	90 minutes	15 minutes

4.1.6.7.10 Neutral Density Profile (DoD/DOC). Measurements of upper atmospheric densities.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage	90 km to Satellite Altitude	90 to 1600 km
b. Horizontal Cell Size	500 km	250 km
c. Vertical Cell Size		
1. Up to 120 km	5 km	0.5 km
2. Above 120 km	5 km	3 km
d. Measurement Range		
1. Atmospheric Density	$8.5x10^{-18}$ to $5x10^{-9}$ g cm^{-3}	$2x10^{-19}$ to $5x10^{-9}$g cm^{-3}
2. Number density	10^{6} to $6x10^{13}$ cm^{-3}	$9x10^{4}$ to $6x10^{13}$ cm^{-3}
3. Neutral composition		N_2, O_2, O, He, H
e. Measurement Uncertainty		
1. < 500 km	10 %	5 %
2. 500 to 700 km	15 %	10 %
3. > 700 km	20%	15 %
f. Latency	90 minutes	15 minutes

4.1.6.7.11 Medium Energy Charged Particles (DoD/DOC). Measurements of particles through this energy range.

Systems Capabilities	Thresholds	Objectives
a. Measurement Range		
1. Energy:		
i. ions	50 keV to 10 MeV in 6 bands	50 keV to 10 MeV in 6 bands
ii. electrons	50 keV to 4 MeV in 5 bands	50 keV to 4 MeV in 5 bands
2. Total Flux:	10^{6} to 5 x 10^{11} $m^{-2}s^{-1}ster^{-1}$	$5x10^{5}$ to 2 x 10^{12} $m^{-2}s^{-1}ster^{-1}$
b. Measurement Precision	Gtr of 10^{6} m^{-2} s^{-1} $ster^{-1}$ or 5 %	Gtr of 10^{5} m^{-2} s^{-1} $ster^{-1}$ or 1 %
c. Measurement Accuracy	15 %	10 %
d. Latency	90 minutes	15 minutes

4.1.6.7.12 Energetic Ions (DoD/DOC). Measurements of high energy ions.

Systems Capabilities	Thresholds	Objectives
a. Measurement Range		
1. Energy (p^{+})	10 MeV to 300 MeV in 4 bands	10 MeV to 400 MeV in 5 bands
2. Flux		
i. p^{+}<100 MeV	$5x10^{3}$ to $2x10^{9}$ m^{-2} s^{-1} $ster^{-1}$	$5x10^{3}$ to $2x10^{9}$ m^{-2} s^{-1} $ster^{-1}$
ii. p^{+} >100 MeV	10^{3} to $3x10^{8}$ m^{-2} s^{-1} $ster^{-1}$	10^{3} to $3x10^{8}$ m^{-2} s^{-1} $ster^{-1}$
3. Linear Energy Transfer (Heavy Ions)		0.1 to 100 MeV cm^{2} mg^{-1}
b. Measurement Precision:		
1. Flux		
i. p^{+} < 100 MeV	Greater of $5x10^{3}$ m^{-2} s^{-1} $ster^{-1}$, or 5 %	Gtr of $5x10^{3}$ m^{-2} s^{-1} $ster^{-1}$, or 1 %
ii. p^{+} > 100 MeV	Greater of 10^{3} m^{-2} s^{-1} $ster^{-1}$, or 10 %	Gtr of 10^{3} m^{-2} s^{-1} $ster^{-1}$, or 2 %

c. Measurement Accuracy:		
1. Flux		
i. $p^+ < 100$ MeV	Gtr of $5x10^3$ $m^{-2}s^{-1}ster^{-1}$ or 20 %	Gtr of $5x10^3$ $m^{-2}s^{-1}ster^{-1}$ or 10 %
ii. $p^+ > 100$ MeV	Gtr of 10^3 $m^{-2}s^{-1}ster^{-1}$ or 10 %	Gtr of 10^3 $m^{-2}s^{-1}ster^{-1}$ or 2 %
d. Latency	90 minutes	15 minutes

4.1.6.7.13 Supra-thermal through Auroral Energy Particles (DoD/DOC). Measurements of particles through this energy range.

Systems Capabilities	Thresholds	Objectives
a. Measurement Range		
1. Energy	30 eV to 50 keV	30 eV to 50 keV
2. Diff. Dir. energy flux:		
i. Electrons	10^9 to 10^{14} $m^{-2}s^{-1}ster^{-1}$	10^9 to 10^{14} $m^{-2}s^{-1}ster^{-1}$
ii. Ions	10^9 to 10^{13} $m^{-2}s^{-1}ster^{-1}$	10^9 to 10^{13} $m^{-2}s^{-1}ster^{-1}$
b. Measurement Accuracy		
1. Pass band center energy	2 %	2 %
2. Diff dir energy flux	Gtr of 10^9 $m^{-2}s^{-1}ster^{-1}$ or 15 %	Gtr of 10^9 $m^{-2}s^{-1}ster^{-1}$ or 15 %
c. Latency	90 minutes	15 minutes
d. Measurement Uncertainty		
1. Particle Energy	20 %	15 %

4.1.6.8 Potential Pre-planned Product/Process Improvements (P^3I). This paragraph describes elements of the NPOESS mission needs having potentially restrictive technical or programmatic uncertainties identified as a result of Phase 0/1 studies. DOC and DoD maintain a need for these observations. The NPOESS program allows for continued examination of possible solutions to these needs, including new or modified instrumentation in future space segments beyond NPOESS IOC. Candidate technologies for meeting these needs shall be examined throughout the course of the program.

4.1.6.8.1 Tropospheric Winds (DOC/DoD). Wind measured throughout the troposphere. Wind profile required for cloud returns and planetary boundary layer aerosol returns.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage		Surface to 20 km
b. Horizontal Resolution		50 km
c. Vertical Reporting Interval		0.1 km
d. Mapping Uncertainty		10 km
e. Measurement Range		0 to 100 m s^{-1}
f. Measurement Precision		0.5 m s^{-1}, vector winds
g. Measurement Accuracy		± 1 m s^{-1}, horiz. components
h. Latency		15 min
i. Refresh		1 hour

4.1.6.8.2 CH_4 (Methane) Column (DOC). Measure of amount of methane contained in a specified volume of air.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage		Total column
b. Horizontal Resolution		100 km
c. Mapping Uncertainty		25 km
d. Measurement Range		40 to 80 μmoles cm^{-2}
e. Measurement Precision		1 %
f. Measurement Accuracy		5 %
g. Latency		15 min
h. Refresh		24 hours

4.1.6.8.3 CO (Carbon Monoxide) Column (DOC). Measure of carbon monoxide in a specified volume of air.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage		Total column
b. Horizontal Resolution		100 km
c. Mapping Uncertainty		25 km
d. Measurement Range		0 to 7 μmoles cm^{-2}
e. Measurement Precision		3 %
f. Measurement Accuracy		±5 %
g. Latency		15 min
h. Refresh		24 hours

4.1.6.8.4 CO_2 (Carbon Dioxide) Column (DOC). Retrievals of column and total carbon dioxide, calibrated by the users with ground-based measurements, of stated precision needed to afford deduction of long-term variations and trends.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage		Total column
b. Horizontal Resolution		100 km
c. Mapping Uncertainty		25 km
d. Measurement Range		11,000 to 15,000 μmoles cm^{-2}
e. Measurement Precision		15 to 20 μmoles cm^{-2}
f. Measurement Accuracy		TBD
g. Latency		15 min
h. Refresh		24 hours

NOTE: Carbon dioxide, carbon monoxide, and methane column data are required by NOAA to accomplish its climate mission. In order to predict the concentrations of trace gases in the troposphere, the spatial distributions of the sources and sinks of these gases shall be known. For species with long atmospheric lifetimes, this requires very precise total column data. Values of the absolute accuracies of these gases needed for adequate predictions would not be as strict as the precision requirements due to the availability of supporting ground-based measurements. Long-term trends/variations in the amounts of these gases in the atmosphere are almost certainly addressed best by carefully calibrated ground-based measurements. However, the satellite retrievals would allow for important assessments of the geographical distribution of patterns or gradients in the trace gas concentrations that are not feasible otherwise.

4.1.6.8.5 Optical Backgrounds (DoD). Emissions are the result of interactions between precipitating energetic particles and solar ultraviolet radiation with neutral atmospheric constituents.

Systems Capabilities	Thresholds	Objectives
a. Coverage		Global
b. Horizontal Resolution		10 km
c. Mapping Uncertainty		50 km
d. Measurement Range		
1. Wavelength		1 to 29 microns, 0.4 to 0.7 microns, 0.04 to 0.2 microns
2. Brightness		TBD
e. Measurement Precision		TBD
f. Measurement Accuracy		TBD
g. Latency		15 min
h. Refresh		each orbit

4.1.6.8.6 All Weather Day/Night Imagery (DoD/DOC). All weather day/night imagery of selected regions. Imagery shall allow discernment of environmental phenomena, including sea ice (by either manual analysis or automated algorithms) and provide digital input to remote sensing algorithms which produce other EDRs.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Spatial Resolution		
1. Regional Scale	100 m (50 m pixels, 8-16 looks)	50 m (25 m pixels, 8-16 looks)
2. Littoral Scale	25 m (12.5 m pixels, 4-8 looks)	12.5 m (6.25 m pixels, 4-8 looks)
3. Local Scale	5 m (2.5 m pixels, 2-3 looks)	1 m (0.5 m pixels, 2-3 looks)
b. Swath Width		
1. Regional Scale	500 km	1000 km
2. Littoral Scale	130 km	200 km
3. Local Scale	30 km	100 km
c. Mapping Uncertainty		
1. Regional Scale	100 m	50 m
2. Littoral Scale	25 m	12.5 m
3. Local Scale	5 m	1 m
d. Refresh		
1. Regional Scale	48 hours	24 hours
2. Littoral Scale	24 hours	12 hours
3. Local Scale	12 hours	1 hours
e. Radiometric Accuracy	1.5 dB	1.0 dB

f. Long-Term Stability	1.0 dB Absolute	0.5 dB Absolute
g. Latency	2 hr	1 hr
h. Geographic Coverage	30 min per orbit on-time. Map ice-covered regions of globe and U.S. Coasts every 3 days. Cover selected areas worldwide. No data below 15 degrees incidence angle.	½ orbit on-time. Map ice-covered regions of globe and U.S. Coasts every 3 days. Cover selected areas worldwide. No data below 15 degrees incidence angle.
i. Orbit Constraints	Global Accessibility. No hole at the pole.	Global Accessibility. No hole at the pole.
j. Retasking	2 hr	1 hr

4.1.6.8.7 Sea and Lake Ice Concentration/Age/Motion/Edge Location (DOC)/(DoD). Ice properties derived from imagery. The requirements below apply under both clear and cloudy conditions for sea ice and ice in the Great Lakes. This requirement applies to ice covered oceans and lakes.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage	Ice Surface	Ice Surface
b. Horizontal Cell Size		
Ice Concentration/ Age/Motion/Edge Location (all weather)	0.1 km	0.05 km
c. Mapping Uncertainty	0.1 km	0.05 km
d. Measurement Range		
1. Ice Concentration	1/10 to 10/10 (10-100 %)	0/10 to 10/10 (0-100 %)
2. Ice Age	Ice free, young, First year, multiyear	Ice free, Nilas, Grey White, Grey White, First Year Medium, First Year Thick, Second Year, and Multiyear Smooth and Deformed Ice
3. Ice Motion	0-75 km day^{-1}	0 to 75 km day^{-1}
4. Edge Location	36^0 –90^0N and 50^0 to 80^0 S	36^0 –90^0N and 50^0 to 80^0 S
e. Measurement Uncertainty		
1. Ice Concentration	10%	5% increments
2. Ice Age (probability of correct typing)	85%	95%
3. Ice Motion	0.2 km day^{-1}	0.1 km day^{-1}
4. Edge Location	0.1 km	0.1 km
f. Refresh	24 hours	6 hours
g. Long-Term Stability		
1. Ice Concentration	1 % $decade^{-1}$	
2. Noise Equivalent sigma 0	-30 dB	-32 dB
i. Range of Incident angles	25 to 55°	25 to 55°
j. Geographic Coverage	All ice-covered regions of the global ocean and Great Lakes	Same as Threshold

k. Orbit Constraints	Coverage of all ice-covered regions of world – no hole at the pole	Same as Threshold

4.1.6.8.8. Oceanographic Requirements

4.1.6.8.8.1 Littoral Currents (DoD). Littoral scale, within 100 km of shore, motion of the water column driven by tidal, wind and density forcing. The types of current that shall be measured are tidal, permanent, wave-induced, wind-induced, longshore and rip currents. Currents are a vector quantity with both speed and direction. This EDR is required under all weather and lighting conditions.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage		0 to 30 m
b. Horizontal Cell Size		0.1 km
c. Vertical Cell Size		Average vector for 1 m layers
d. Mapping Uncertainty		0.1 km
e. Measurement Range		0 to 5 m s^{-1}, 0 to 360^o
f. Measurement Precision		0.128 m s^{-1}, 1^o
g. Measurement Accuracy		0.128 m s^{-1}, 1^o
h. Refresh		3 hours
i. Latency		15 minutes

4.1.6.8.8.2 Coastal Ocean Color (DoD/DOC). Coastal coverage refers to the areal extent consistent with the U.S. Exclusive Economic Zones (EEZ) which extend 370 km from shore. Coastal coverage shall entail roughly 300 km swath coverage, but pertains to all coasts worldwide to support civil and military observations. Ocean color is defined as the spectrum of water-leaving radiances (L_w), i.e., the portion of visible – near infrared light that is reflected out of the water column, excluding light reflected at the surface. All geophysical quantities of interest, e.g., the concentration of the phytoplankton pigment chlorophyll *a* (chlorophyll-*a*) and the inherent optical properties of absorption and scattering of surface waters (ocean optical properties), are derived from these L_w values. Water-leaving radiances are measured in W m^{-2} μm^{-1} sr^{-1}. Ocean optical properties, absorption and scattering, are estimated at each measured visible wavelength, and have units of inverse meters (m^{-1}) while Chlorophyll *a* is measured in mg m^{-3}. This EDR is required for clear daytime conditions only, for selected lakes, rivers, estuaries, bays, and other coastal regions that require higher resolution data. Note: Operational requirements are DoD/DOC, while Science requirements are DOC only and permit post-processing with additional ancillary data.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size		
1. Nadir	0.1 km	
2. Worst case	0.2 km	0.1 km
b. Mapping Uncertainty		
1.Nadir	0.1 km	
2.Worst case	0.2 km	0.1 km

c. Measurement Range		
1. Ocean Color	0.10 - 10 W m^{-2} μm^{-1} sr^{-1}	0. 05-10 W m^{-2} μm^{-1} sr^{-1}
2. Optical Properties.		
a) Absorption	0.01- 10 m^{-l}	005 - 20 m^{-l}
b) Scattering	0.02- 50 m^{-l}	0.005 - 75 m^{-l}
c) Chlorophyll fluorescence	Detectable signal in waters with chlorophyll from 0.25 to 50 mg m^{-3} at 1 km resolution	Detectable signal in waters with chlorophyll from 0.1 to 50 mg m^{-3} at 1 km resolution
3. Chlorophyl	0.01 to 50 mg m^{-3}	0.001-100 mg m^{-3}
d. Measurement Precision		
1. Ocean Color		
a)Operational	5 %	2 %
b) Science Quality	2 %	1 %
2. Optical Properties		
a).Operational	20 %	20 %
b) Science Quality	20 %	10 %
3. Chlorophyll		
a).Operational	20 %	10 %
b) Science Quality	10 %	5 %
e. Measurement Accuracy		
1. Ocean Color		
a)Operational	10 %	5 %
b) Science Quality	5 %	3 %
2. Optical Properties		
a).Operational	40 %	30 %
b) Science Quality	30 %	20 %
3. Chlorophyll		
a).Operational	40 %	20 %
b) Science Quality	30 %	10 %
f. Refresh	24 hours	4 hours
g. Long-Term Stability		
At wavelength of Max Chlorophyll Absorption	0.50 W m^{-2} μm^{-1} sr^{-1}	0.250 W m^{-2} μm^{-1} sr^{-1}
At wavelength of Min Chlorophyll Aborption	0.2 W m^{-2} μm^{-1} sr^{-1}	0.125 W m^{-2} μm^{-1} sr^{-1}
At near IR wavelength used for Atmospheric Correction	0.08 W m^{-2} μm^{-1} sr^{-1}	0.040 W m^{-2} μm^{-1} sr^{-1}
h. Latency		
1. Operational	3 hours	1 hour
2. Science Quality	48 hours	24 hours
i. Geographic Coverage	Selected coastal regions, rivers and lakes, U.S. and worldwide	Selected coastal regions, rivers and lakes, U.S. and worldwide

4.1.6.8.8.3 Bioluminescence Potential (DoD). An estimate of the potential number of flashes generated by bioluminescent organisms present in sea water within a region.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Resolution		
Nadir	1.0 km	
Worst case	2.4 km	0.65 km
b. Mapping Uncertainty		
Nadir	1.0 km	
Worst case	3 km	0.5 km
c. Measurement Accuracy		TBD
d. Refresh	24	12
e. Long-Term Stability	TBD	TBD
f. Latency	3 hours	1 hour
g. Geographic Coverage	Global	Global

4.1.6.8.8.4 Coastal Sea Surface Temperature (SST) (DOC/DoD). Coastal coverage refers to the areal extent consistent with the U.S. Exclusive Economic Zones (EEZs) which extend 370 km from shore. Coastal coverage shall entail roughly 300 km swath coverage, but pertains to all coasts worldwide to support civil and military observations. Sea surface temperature is defined as the temperature of the surface layer (upper 1 meter) of ocean water. It has two major applications: 1) sea surface phenomenology, and 2) use in infrared cloud/no cloud decision for processed cloud data. The requirements below apply only under clear conditions for selected lakes, rivers and coastal regions that require high resolution data.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size		
Nadir	0.1 km	
Worst case	0.2 km	0.1 km
b. Mapping Accuracy		
Nadir	0.1 km	
Worst case	0.2 km	0.1 km
c. Measurement Range	-2^{o} to 40^{o} C	-2° to 40° C
d. Measurement Precision	0.4^{o} C	0.1° C
e. Measurement Uncertainty	0.7° C	0.2° C
f. Refresh	12 hours	6 hours
g. Long-Term Stability	TBD	
h. Latency	2 hr	1 hr
i. Geographic Coverage	U.S. coastal areas and selected coastal areas and lakes worldwide	Same as Threshold

4.1.6.8.8.5 Coastal Sea Surface Winds (Speed and Direction) and Wind Stress (DOC). Coastal coverage refers to the areal extent consistent with the U.S. Exclusive Economic Zones (EEZ) which extend 370 km from shore. Coastal coverage shall entail roughly 300 km swath coverage, but pertains to all coasts worldwide to support civil and military. This EDR also pertains to selected open ocean areas. Measure of atmospheric wind speed/direction at the sea/atmosphere interface (10 meter height neutral stability winds) in clear sky and cloudy conditions, for integrated rainfall rates less than 2 mm hr^{-1} km^{-2}. Wind stress measurements observe the frictional stress of the wind acting on the sea surface, causing it to move as a wind-drift current, and causing the formation of waves.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	1 km	300m
b. Minimum distance to shore	1 km	300 m
c. Mapping Uncertainty	1 km	300 m
d. Measurement Range		
1 Wind Speed/Direction	3 to 35 m s^{-1}, 0 to 360^o	2 to 50 m s^{-1}, 0 to 360^o
2. Wind Stress	0 to 3 N m^{-2}, 0-360^o	0 to 10 N/m^2, 0-360^o
e. Measurement Uncertainty (Wind Speed and Direction)		
1. Speed**	greater of 2 m s^{-1} or 10 %	greater of 1 m s^{-1} or 10 %
2. Direction***	TBD	10^o
f. Measurement Precision (Wind Stress)		
1. Stress	0.02 N m^{-2}	0.01 N m^{-2}
2. Stress Direction	TBD	TBD
g. Measurement Accuracy (Wind Stress)		
Speed	0.02 N m^{-2}	0.01N m^{-2}
Direction	TBD	TBD
h. Refresh	6 hours	2 hours
i. Latency	2 hours	1 hour
j. Geographic Coverage	U.S. EEZ up to coast and in lakes, bays and estuaries; selected open ocean regions worldwide not to exceed 30 minutes each orbit	U.S. EEZ up to coast and in lakes, bays and estuaries; selected open ocean regions worldwide not to exceed 30 minutes each orbit

** Not more than 25% of the wind speed uncertainty should be attributed to a wind speed bias (i.e., no more than 6.25% of the square of the RMS error should be due to the bias).

*** Direction uncertainty is to be applied to the unique chosen ambiguity.

4.1.6.8.8.6 Sea Surface Height Coastal (DOC/DoD). This EDR differs from Sea Surface Height in section 4.1.6.6.7 by having much more stringent sampling and timeliness requirements. Sea surface height is the topography of the ocean surface with respect to the Earth's reference ellipsoid defined in a well-maintained terrestrial reference frame.. Coastal sea level variability is required for estimation of tides and tidal currents. The requirements below apply under both clear and cloudy conditions.

Note: the following terminology is altimeter-specific. See Glossary Part II for Terms and definitions specific to sea surface height.

Systems Capabilities	Threshold	Objective
a. Horizontal Resolution		
1. Satellite Nadir Resolution		0.3 km
2. Horizontal Reporting Interval		0.3 km
3. Closest point to shore		0 km
b. Measurement Precision		2 cm
c. Measurement Accuracy		4 cm
d. Exact Repeat Period		3 hours
e. Equatorial Track Spacing		1 km
f. Latency		1 hour
g. Geographic Coverage		85S to 85N latitude
h. Long Term Stability		1mm yr^{-1}

4.1.6.8.8.7 Coastal Imagery (DoD/DOC). Coastal coverage refers to the areal extent consistent with the U.S. Exclusive Economic Zone (EEZ) which extends 370 km from shore. Coastal coverage shall entail roughly 300 km swath coverage, but pertains to all coasts worldwide to support civil and military observations. Specialized imagery at sufficient resolution to enable discernment of environmental phenomena (by either manual analysis or automated algorithms) for oceanographic observations. Imagery shall provide digital input, through single bands and/or combinations of band/channels, to remote sensing algorithms which produce other environmental measurements, although this does not replace the explicit requirement for retrieval of individual parameters described elsewhere in this document.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size		
1. Nadir	0.1 km	
2.Worst case	0.2 km	0.1 km
b. Mapping Uncertainty		
1.Nadir	0.1 km	
2.Worst case	0.2 km	0.1 km
c. Refresh	12 hours	6 hours
d. Long-Term Stability	N/A	
e. Latency	2 hrs	1 hr
f. Geographic Coverage	U.S. coastal areas and selected coastal areas and lakes worldwide	Same as Threshold

4.1.6.8.8.8 Ocean Wave Characteristics - Ocean Wave Direction / Wavelength (DoD/DOC). The direction and wavelength of ocean waves. The requirements below apply under both clear and cloudy conditions. Note 1: Refresh requirement is to provide observations along the satellite nadir-track of any satellite carrying an altimeter if an altimeter is used, or within the footprint of an Active Microwave scene, if applicable.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	2.5 – 20 km (Sea state dependent)	2.5km
b. Mapping Uncertainty	10 km	5 km
c. Measurement Range		
1. Wavelength	100-700 m	50-700 m
2. Direction	0 to 360^o	0 to 360^o
d. Measurement Precision		
1. Wavelength	10 m	5 m
2. Direction	10^o	5^o
e. Measurement Accuracy		
1. Wavelength	10 m or 10 %, whichever is greater	5 m or 5 %, whichever is greater
2. Direction	10^o	5^o
f. Refresh	See Note 1	See Note 1
g. Latency	2 hours	1 hour
h. Geographic Coverage	Global Ice-free Oceans	Global Ice-free Oceans

4.1.6.8.8.9 Surf Conditions (DoD). This is a Navy requirement to support amphibious and special operations. This is also useful for monitoring/predicting coastal erosion. Characterize surf height, type and period/wavelength in all weather conditions.

a. Location of Surf Zone (DoD). This defines the location of the breaking waves and how far from shore the waves start to break. The location of the surf zone should not change very rapidly, although it will depend on the sea state (thus an increasing sea state may increase wave height, thus increase the distance from shore of breaking waves) which can change on the scale of a few hours. However, if one knows the surf zone location for the last 12 hours, it may still be a useable estimate.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Spatial Resolution		
1. Cross-shore cell size	0.025 km	0.01 km
2. Along-shore cell size	0.1 km	0.1 km
b. Mapping Uncertainty	0.01 km	0.001 km
c. Measurement Range	0-100 m	0-100 m
d. Measurement Precision	10 m	1 m
e. Measurement Accuracy	10 m	1 m
f. Refresh	12 hours	1 hour

b. Breaking Wave Height. This defines the height of the breaking wave within the surf zone. This will determine whether a landing is even possible and is an essential piece of information for the surf zone index

Systems Capabilities	Thresholds	Objectives
a. Horizontal Spatial Resolution		
1. Cross-shore cell size	0.025 km	0.01 km
2. Along-shore cell size	0.1 km	0.01 km

b. Mapping Uncertainty	0.01 km	0.001 km
c. Measurement Range	0-5 m	0-5 m
d. Measurement Precision	0.5 m	0.5 m
e. Measurement Accuracy	0.5 m	0.5 m
f. Refresh	12 hours	1 hour

c. Surf Zone Currents. This defines the currents in the proximity of the surf zone and is necessary for amphibious operations during STOM (Ship To Objective Maneuver) operations.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Spatial Resolution		
1. Cross-shore cell size	0.025 km	0.05 km
2. Along-shore cell size	0.1 km	0.05 km
b. Mapping Uncertainty	0.25 km	0.001 km
c. Measurement Range	0-3 m s^{-1}	0-3 m s^{-1}
d. Measurement Precision	0.25 m s^{-1}	0.1 m s^{-1}
e. Measurement Accuracy	0.25 m s^{-1}	0.1 m s^{-1}
f. Refresh	12 hours	1 hour

d. Surf Zone Bathymetry. This defines the depth of water in the proximity of the surf zone and allows commanders to determine which systems (surface and sub-surface) will be capable of operations in that area.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Spatial Resolution		
1. Cross-shore cell size	0.025 km	0.001 km
2. Along-shore cell size	0.1 km	0.005 km
b. Mapping Uncertainty	0.025 km	0.001 km
c. Measurement Range	0-5 m	0-5 m
d. Measurement Precision	0.5 m	0.1 m
e. Measurement Accuracy	0.5 m	0.1 m
f. Refresh	1 week	1 week

4.1.6.8.8.10 Bathymetry (Deep Ocean and Near Shore) (DoD). Vertical depth of water. Note: Requires SAR/hyperspectral for coastal areas and next generation altimeter for deep ocean.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage		
1. Deep Ocean		200 to 5000 m
2. Near shore		0 to 200 m, See Note 1
b. Horizontal Resolution		
1. Deep Ocean		300 m
2. Near shore		30 m
c. Vertical Cell Size		
1. Deep Ocean		1 m
2. Near Shore		0.5 m
d. Mapping Uncertainty		10 m
e. Measurement Accuracy		0.3 m

f. Refresh		48 hours
g. Latency		4 hours

Note: "Near Shore" means "outside of the surf zone."

4.1.6.8.8.11 Salinity (DoD/DOC). This parameter is the quantity of dissolved materials in sea water. A formal definition is "the total amount of solid materials, in grams, contained in one kilogram of sea water, when all the carbonate has been converted to oxide, the bromine and iodine converted to chlorine, and all organic matter is completely oxidized." Traditional units of measurement are parts per thousand (ppt), by weight; however, today, a "practical salinity scale" based on the ratio of the electrical conductivity of a seawater sample to that of standard seawater at 35 ppt is commonly used.

Systems Capabilities	Thresholds	Objectives
a. Vertical Coverage	Surface	0 to 300 m
b. Horizontal Resolution	75 km	0.25 km
c. Vertical Cell Size	N/A	2 m
d. Mapping Uncertainty	20 km	0.25 km
e. Measurement Range	32 to 38 ppt	0 to 40 ppt
f. Measurement Precision	0.1 ppt (global)	0.5 ppt (regional) 0.05 ppt (global)
g. Measurement Accuracy	0.1 ppt (global)	0.5 ppt (regional) 0.05 ppt (global)
h. Refresh	7 days	3 hours
i. Latency	90 minutes	15 minutes

4.1.6.8.8.12 Oil Spill Location (DOC). All-weather, day/night, high-resolution maps of oil spills on the ocean, on lakes, and on larger rivers. Only regional coverage is required for selected monitoring areas. Tasking must be rapid (24 hours or less) to respond to spills as they occur in U.S. waters and other regions of interest worldwide. The threshold output product is an oil/no oil determination on a map. The objective output product further distinguishes between biogenic and mineral oil.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size		
1.Regional Scale	50 m (8-16 looks)	25 m
2. Littoral Scale	12.5 m (4-8 looks)	6.25 m
3. Local Scale	5 m (2-3 looks)	0.5 m
b. Mapping Uncertainty		
1.Regional Scale	100 m	50 m
2. Littoral Scale	25 m	12.5 m
3. Local Scale	5 m	1 m
c. Measurement Range (within a wind speed range of 3-12 m s^{-1})	oil/no oil differentiation	Oil/no oil and natural seep or spill / biogenic slick differentiation

d. Measurement Precision		
1.Regional Scale	50 m	25 m
2. Littoral Scale	12.5 m	6.2 m
3. Local Scale	2.5 m	0.5 m
e. Measurement Accuracy	70 % correctly detected	90 % correctly detected and classified
f. Refresh	2 days	3 hours
g. Long-Term Stability	±0.5 dB instrument to instrument	±0.2 dB instrument to instrument
h. Latency	2 hours	1 hour

4.1.6.8.9 Vertical Hydrometeor Profile (DOC). Vertical profile of precipitating water and precipitating ice (mean in volume).

Systems Capabilities	Thresholds	Objectives
a. Horizontal Resolution	25 km	5 km
b. Vertical Resolution	3 km	2 km
c. Mapping Accuracy	5 km	1 km
d. Range	0-3.0 g m^{-3}	0-3.0 g m^{-3}
e. Precision	greater of 0.2 g m^{-3} or 10%	greater of 0.1 g m^{-3} or 4 %
f. Accuracy	greater of 0.4 g m^{-3} or 25%	greater of 0.2 g m^{-3} or 10 %
g. Refresh	6 hours	4 hours
h. Long-term Stability	greater of 0.1 g m^{-3} or 5 %	greater of 0.05 g m^{-3} or 1 %

4.1.6.8.10 Neutral Winds (DoD/DoC). Measurement of the horizontal neutral wind in the upper thermosphere.

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size	250 km	250 km
b. Vertical Cell Size	15 km	15 km
c. Horizontal Coverage	Global	Global
d. Vertical Coverage	90 to 500 km	90 to 500 km
e. Measurement Range	0 to ±1500 m s^{-1}	0 to ±1500 m s^{-1}
f. Measurement Uncertainty	Greater of 5 m s^{-1} or 5 %	Greater of 5 m s^{-1} or 5 %
g. Latency	90 minutes	15 minutes

4.1.7 Interfaces

Interface is defined as the ability for two entities to physically or electronically interact and/or communicate with each other.

4.1.7.1 Space Segment Interfaces

4.1.7.1.1 Space Segment Interface to Launch Segment. The satellite should be designed to require minimal preparation at the launch site. When a launch is required, existing U.S. launch site facilities will be used to the maximum extent possible.

4.1.7.1.2 Space Segment Interface to C^3 Segment. The Space Segment shall support all of the Command, Control and Communication interfaces (as identified in the NPOESS Technical

Requirements Document (TRD)) that enable Telemetry and Commanding, Stored Mission Data Delivery and real time broadcasts (HRD and LRD). All communication links to and from the Space Segment (with exception of search and rescue, and surface data collection transmissions) shall provide the capability to preclude interference or unauthorized contact.

4.1.7.1.3 Space Segment Interface to Field Terminals. The Space Segment shall provide real time data to the Field Terminals. Field terminals, in existence at the time of the first NPOESS launch, shall interface with the NPOESS Space Segment.

4.1.7.1.4 Surface Data Collection (SDC) Interface to/from Space Segment. This interface shall enable the receipt of data from ARGOS platforms (or its follow-on) by NPOESS satellites and the transmission of forward messaging data to suitably equipped platforms.

4.1.7.1.5 Search and Rescue (SAR) Interface to/from Space Segment. This interface shall enable the receipt of SAR transmissions by the satellite and the rebroadcast of SAR data by the Search and Rescue Repeater (SARR) hosted on the satellite.

4.1.7.2 Launch Support Segment Interfaces. The Launch Support Segment shall interface with the launch site, Space Segment, and C^3 Segment to conduct launch of all NPOESS satellites.

4.1.7.3 C^3 Segment Interfaces

4.1.7.3.1. C^3 Interfaces to Scheduling Resources. Depending on the use of Universal S-band (USB) compatible Air Force Satellite Control Network (AFSCN) sites, other USB sites, or the NASA Space Network (SN), the C^3 Segment shall interface with the appropriate scheduling agency.

4.1.7.3.2. C^3 Interfaces for Orbit Determination. Primary on-board orbit determination shall be performed by a Global Positioning Receiver using Selective Availability Anti-Spoofing Module (SAASM)-based equipment. NPOESS requires appropriate backup capabilities, to include interfaces with the Cheyenne Mountain Operations Center (CMOC) to acquire orbital element sets, as necessary.

4.1.7.3.3. C^3 Interfaces to the Centrals' IDP Segment. The interface from the C^3 segment to the IDP Segment shall minimize impact on existing Centrals.

4.1.7.4. IDP Segment Interfaces

4.1.7.4.1. IDP Segment Interface to the Centrals. The IDP Segment shall provide NPOESS data (xDRs) to Centrals. The IDP Segment shall be capable of receiving data from the Centrals.

4.1.7.4.2. IDP Segment Interface to the Field Terminals. IDP Segment functionality to receive and process real-time NPOESS data shall be integrated into field terminals.

4.1.8. Flexibility and Expansion. All systems shall, where practical, incorporate designs that allow for variations in operation without system redesign. Systems' processes shall be modular to reduce maintenance and promote reusability.

4.1.9 IDP Segment Computer Capacity. The IDP Segment shall have the capacity to ingest, process, and store twice the worst case data loading scenario required to produce the full complement of NPOESS RDRs, SDRs, and EDRs as projected for FOC at CDR. The intent is to support the nominal NPOESS constellation and any residual NPOESS satellites that may be on orbit.

4.2 Information Exchange Requirements

Top-level Information Exchange Requirements are included with the Interoperability KPP listed in 5.3.5 and Table B.

4.3 Logistics and Readiness

4.3.1 System Operational Availability (A_O). A_O is the probability that a system can be used for any specified purpose when desired. The system Operational Availability for NPOESS will be 93% (Threshold) and 95% (Objective) for both wartime and peacetime. The system A_O is a composite value including space segment, C^3, and IDP Segment over the life of the program averaged over all orbital planes. A_O is defined as:

A_O = uptime/total time = [MTBDE / (MTBDE + MDT)] x 100%

Where MTBDE is the Mean Time Between Downing Events (critical or non-critical failures, preventive maintenance, training, maintenance and supply response, administrative delays, and actual on-equipment repair that cause a loss of the ability to deliver an EDR that contains a KPP) and MDT is the Mean Down Time (time required to restore a system to full operating status). For each orbital plane of the space segment, MDT includes launch call up and satellite activation time.

MTBDE = [Number of Operating Hours] / [Number of Downing Events]

MDT = [Total Down Time] / [Number of Downing Events]

4.3.2 Space Segment

4.3.2.1 Minimum Useful Space Segment Lifetime (MUSSL). The NPOESS space segment shall support a total mission life cycle of 10 years.

4.3.2.2 Maintainability. The spacecraft design shall include maintainability features to ensure timely replacement or test of spacecraft subsystems or sensors prior to launch. Space-based elements of the system shall not require maintenance or repair during on-orbit service life (i.e., no on-orbit maintenance is planned for the system).

4.3.3 NPOESS C^3 Segment Ground Equipment and IDP Segment Equipment. Systems' processes shall be modular to reduce maintenance and promote reusability. USG requires that all NPOESS Ground Equipment, Hardware and Software (C^3, IDP Segment, and Field Terminals) shall be supplied with diagnostics capability for fault isolation and remediation. This shall include not only OEM diagnostics, but also similar capability for all special or unique subsystems that make up part of the NPOESS Ground Equipment. Fault isolation equipment may be independent systems or subsystems (hardware or software) within the NPOESS Ground Equipment operational configuration.

4.3.3.1 Fault Detection. Built-In-Test (BIT)/Built-In-Test-Equipment (BITE) fault detection shall detect at least 98%, with an objective of 99%, of the single unit failures occurring within a system.

4.3.3.2 Fault Isolation. Built-In-Test (BIT)/Built-In-Test-Equipment (BITE) fault isolation shall identify the failed line replaceable unit (LRU) at least 98% of the time, with an objective of 99% success. The fault isolation routine shall also be capable of operator-initiation.

4.3.3.3 Notification of System Faults. The USG requires detection of a system fault immediately, implementation of a workaround for the fault within 30 minutes, and complete fault isolation and correction as soon as possible after detection while maintaining the required operational availability, A_O. As an objective, the Ground Equipment with the failed component(s) should be returned to operations within 4 hours.

4.4 Environmental, Safety and Occupational Health (ESOH) and Other System Characteristics

4.4.1 Nuclear, Biological and Chemical (NBC) Survivability. The DMSP/NPOESS STAR describes the NBC threat. IORD Attachment 2 contains the NPOESS survivability requirements.

4.4.2 Natural Environmental Factors

4.4.2.1 Space Segment. The NPOESS spacecraft shall operate reliably in the specific space environment for which it is intended (i.e., no major degradation caused by its environment over its design life).

4.4.2.2 C^3 Segment. The NPOESS C^3 segment shall operate reliably in the specific natural environment for which it is intended (i.e., no major degradation caused by its environment over its design life).

4.4.2.3 Interface Data Processor Segment. Impact to the Centrals IDP Segment, from the operational environment, shall be minimized. All centralized processing facility equipment shall be located in environmentally controlled facilities with both short term (uninterruptible) and long term backup power. Any equipment located outside of the environmentally controlled facilities shall be constructed to withstand local weather conditions.

4.4.3 Safety Parameters

4.4.3.1 Range Safety Compliance. Spacecraft developed for this program will comply with applicable Eastern/Western Range requirements.

4.4.3.2 End-of-Life Safety. NPOESS spacecraft shall be designed, as a threshold, to comply with the space debris minimization policies outlined in section 4.1.5.9.

4.4.4 Security. Security requirements shall be responsive to the identified threat as defined in Section 2 of this document. System security shall be engineered into the design and manufacturing of all parts in this system in accordance with DoDI 5000.2 (and appropriate tri-agency documents as determined in accordance with the tri-agency Memorandum of Agreement for the NPOESS), to protect critical components from compromise.

4.4.4.1 Information Security. Information security is a combination of administrative policies and procedures for identifying, controlling, and protecting information from unauthorized disclosure. NPOESS information security shall comply with applicable DoD and DOC directives, as well as yet to be developed IPO program protection guidance.

4.4.4.2 Personnel Security. The NPOESS personnel security program shall be managed IAW DoD, DOC, and NASA directives, as applicable.

4.4.4.3 Physical Security. Physical security and resource protection for the NPOESS shall be provided and managed IAW DoD, DOC, and NASA directives, as applicable.

4.4.4.4 Industrial Security. NPOESS procedures and methods for protecting classified information in the possession of DOC, NASA, and DoD personnel and government contractors shall be developed and managed following applicable directives.

4.4.4.5 COMSEC, OPSEC, TEMPEST, COMPUSEC Thresholds

4.4.4.5.1 COMSEC. Communications security (COMSEC) measures provide protection for the transmission of sensitive information. All downlink signals from the satellites, with the exception of Surface Data Collection/location and Search and Rescue data, shall be capable of being denied to selected users. All commands uplinked to the satellite shall be encrypted and pass through an authentication procedure on the spacecraft. A failure to be authenticated shall cause a command not to be executed. The results of the attempt to authenticate uplinked commands by the satellite shall be transmitted over a telemetry link to the C^3 Segment.

4.4.4.5.2 Operations Security (OPSEC). The NPOESS design shall protect information that could reveal system plans, procedures, or missions. NPOESS OPSEC procedures shall be developed IAW DoD, DOC, and NASA directives, as applicable. Protection of critical information requires that DOC, DoD, and contractor personnel practice COMSEC and OPSEC to preclude compromise. Usually, the data collected are unclassified; however, planned acquisition or application of data to a specific military operation could reveal U.S. intentions.

4.4.4.5.3 Compromising Emanations (TEMPEST). The appropriate TEMPEST protection shall be applied to facilities, systems, or equipment that electrically process classified (national security) information. The protection should be proportional to the threat of exploitation and the potential damage to National Security.

4.4.4.5.4 Computer Security (COMPUSEC). Any computer or communications system used in software development or maintenance interfacing with or part of the NPOESS computer system shall comply with the appropriate security class, operating mode, and trusted systems criteria requirements IAW DoD, DOC, and NASA documents as applicable.

4.4.5 Electromagnetic Environmental Effects and Spectrum Supportability

4.4.5.1 Space Segment to C^3 Segment Interface. This interface includes the uplink and downlink Radio Frequency (RF) and data interfaces required for the C^3 Segment. The interface between the Space and C^3 Segments consists of the uplink for command and control, as well as the downlinks for telemetry. This interface shall be compatible with the USB compatible AFSCN/CDA Elements. All uplink command and control data shall be encrypted/decrypted using National Security Agency (NSA) approved devices.

4.4.5.2 Space Segment to Field Terminal Component Interface. This interface includes downlink RF and data interfaces required for field terminals and the first-in systems. The interface consists of data records and ephemeris data downlinks to HRD and LRD field terminals. The interface shall provide automatic tracking whenever the NPOESS satellite is within the field of view of the field terminal and above the signal horizon. Broadcast frequencies selected shall provide sufficient bandwidth to deliver data IAW Table C.

4.4.5.3 C^3 Segment to Central IDP Segment Interface. This includes the communications required to transfer data from the C^3 Segment to the Centrals.

4.4.5.4 Electromagnetic Compatibility. The NPOESS shall be designed to be electromagnetically compatible with itself, with its known equipment, with test equipment, ground support equipment, and with Government furnished equipment (GFE). The Electromagnetic Compatibility (EMC) requirements shall be IAW existing DoD and DOC documentation. All support facilities, including test facilities and launch base facilities, shall comply with the ground requirements.

4.4.5.5 Radio Frequency Spectrum Supportability. All spectrum dependent systems shall comply with all national and international spectrum management policies and regulations. Radio frequency emitters associated with the system must have radio frequency certification and valid radio frequency assignments prior to operational use. Spectrum responsibility includes, but is not limited to certification papers, IAW OMB A11 and valid frequency assignment for all systems prior to operational use. Users of ground terminal equipment shall have the responsibility to comply with the same policies both in the Untied States and internationally prior to operational use.

5.0 Program Support

Integrated Logistics Support is required for all NPOESS C^3 Segment ground equipment located at the SOCs and other NPOESS ground sites, as well as the IDP Segment located at the Centrals and is covered in this section. Hereafter, the term "Ground Equipment" will include both C^3 and IDP Segment equipment unless stated otherwise.

5.0.1 Support Objectives. Interim Contractor Support will be used to support the NPOESS system during the Logistics Support Analysis (LSA) and the design and implementation of support prior to IOC. Support should be provided for ground equipment that is operational at IOC using a mix of Contractor Logistics Support (CLS) and Organic Support as determined to be most cost effective by the LSA. By FOC CLS and Organic Support should be expanded to all ground equipment.

5.0.2 C^3 Subsystem Support. The NPOESS C^3 Segment will provide redundant C^3 capability to meet the data acquisition and constellation management requirements. The majority of the NPOESS C^3 ground equipment will be located at the primary SOC at Suitland, MD and the backup SOC at Schriever AFB, CO. Depending on the final architecture of the Space and C^3 Segments, some unique NPOESS C^3 Ground Equipment may be located at NOAA CDA and other USB compatible ground sites. The integrated NPOESS SOCs are responsible for maintaining the health of the NPOESS spacecraft in orbit. Additionally, the Primary SOC will provide the capability for monitoring and commanding the spacecraft during launch, orbit attainment, and flight checkout. Logistical support to this segment includes maintenance of the systems implemented for constellation management and the communications systems to move the NPOESS sensor data streams to the IDP Segment subsystem.

5.0.3 IDP Segment Subsystem Support. The Interface Data Processor segment of NPOESS provides for the acquisition of raw data streams at Centrals and field sites, and the processing of the RDRs into environmental data records (EDR) for distribution or local use. Logistical support to this segment includes maintenance of the systems implemented to acquire the NPOESS sensor data streams and the systems deployed to produce the EDRs.

5.0.4 Interfacing Systems. The NPOESS design process shall address how the system will be integrated into interfacing systems, including those related to command, control, communications, and intelligence (C^3I); transportation and basing; standardization, interoperability, and commonality; geospatial information services; and environmental support. Each of these areas is addressed below. The DoD Joint Potential Designator is recommended to be "joint", due to the joint management involved (Senior User's Advisory Group, Joint Agency Requirements Council) and probable joint funding.

5.1 Maintenance Planning

The NPOESS C^3 and IDP Segment Ground Equipment will be operated by a mix of USG civilian and military personnel, and contractors. Remedial and preventive maintenance of the Ground Equipment is an NPOESS Integrated Program Office (IPO) function and shall be consistent with stated requirements for overall NPOESS system availability, reliability, and product delivery timeliness.

5.1.1 Maintenance Tasks. Maintenance is required of all NPOESS Ground Equipment including equipment installed at the SOCs, NPOESS unique equipment installed in the NPOESS DRR network, and IDP Segment equipment installed at the Centrals. This maintenance is required during development, installation, Initial Operational Test and Evaluation (IOT&E), Initial Operations, and for 12 months after full operational capability (FOC) is certified (hereinafter referred to as the extended maintenance period). In addition, the NPOESS system delivered shall include options for additional periods of Ground Equipment hardware and software maintenance and upgrades, which will be exercised at the discretion of the USG throughout the program life cycle. The system will have an information technology upgrade strategy consistent with commercial practices.

5.1.1.1 Diagnostic Capabilities. The Ground Equipment is required to have sufficient diagnostic and failure detection capabilities (hardware and software) to detect a system fault immediately and notify operations staff. The Ground Equipment should be configured to allow hardware or software components to be repaired or replaced without the loss of data or spacecraft mission to a level meeting specified NPOESS system availability requirements. Hardware may either be repaired or replaced.

5.1.1.2 Upgrade Strategy. Sufficient redundancy shall exist that hardware and software upgrades can be installed and tested on non-critical portions of the system without affecting the on-going operations. When specifically approved by the USG, some minimal loss of redundancy may be acceptable for such upgrades. Proposals for such operations shall take into account the duration of the procedure to be followed and the potential effect on operations if random failures occur on the remaining operational system before upgrade activities are complete.

5.1.1.3 Hardware Maintenance Tasks.

5.1.1.3.1 Failure Alerts. NPOESS Operations staff will be alerted to system failures as described in Section 4.3.3. Procedures are required to allow operators to determine the consequences (*i.e.*, the effect on NPOESS Space Segment, C^3, or IDP Segment operations) of the failure and take appropriate actions to continue operations without loss of mission or data.

5.1.1.3.2 Preventive Maintenance. Preventive maintenance (including upgrades/configuration changes authorized by IPO) is required to be performed. This maintenance will follow approved procedures and not impact any operational data handling or processing. For configuration changes from the established configuration baselines the IPO Configuration Control Board (CCB) will be the reviewing authority with its Chairperson, the IPO System Program Director having final approval authority. Each agency of the tri-agency IPO will have membership on the CCB through the IPO Assistant Directors.

5.1.1.3.3 Upgrades. Hardware upgrades, including those of non-developmental or commercial off-the-shelf components, needed to ensure continued serviceability and performance reliability of systems during the NPOESS life cycle, are required to be provided on a timely and non-interference basis.

5.1.1.3.4 Initial Maintenance Period. Remedial and preventive maintenance are required on government furnished NPOESS Ground Equipment hardware during the interval beginning with delivery of the GFE to the NPOESS Ground Equipment contractor and continuing up to FOC and acceptance of the NPOESS Ground Equipment. Maintenance provisions will be in addition to those provided by manufacturer's warranties, but do not exclude the use of warranties. Records shall be kept and reports made on all maintenance performed and on engineering changes installed on the GFE prior to acceptance of the NPOESS Ground Equipment.

5.1.1.3.5 Extended Maintenance Period. For the extended maintenance period, both preventive and remedial maintenance are required on all contractor supplied and government furnished NPOESS Ground Equipment hardware.

5.1.1.3.6 C^3 Hardware Special Provisions. On site ground station maintenance of all NPOESS C^3 Ground Equipment is the responsibility of station personnel. Telephone support is required for all ground stations, on a 24 hour per day, 7 day per week basis, to assist in preventive and remedial maintenance. A response time of 30 minutes or less is required for this support. If the problem can not be resolved by telephone, on-site maintenance service to the ground stations will be required. Remedial maintenance activities are required on-site at the location of the failure following notice requesting maintenance service by the contractor in time to support the EDR latency (4.1.5.1.1) and data availability (4.1.5.1.2) requirements .

5.1.1.4 Software Maintenance Tasks. All software maintenance procedures will be approved by the USG. Operations staff must be alerted to a system or applications software failure (logic failure) per Section 4.3.3. Parallel, off-line software testing and integration paths are required that allow software debugging and modifications to be pursued without impacting operations of the NPOESS C^3 or IDP Segment Ground Equipment.

5.1.1.4.1 Software Configuration Management. Software maintenance (*e.g.*, compilation of succeeding revisions of the system software) is expected to be performed by contractor personnel. Additional software maintenance tasks include developing and implementing software modifications needed to ensure compatibility with IDP Segment hardware upgrades, revision of product validation software and upgrades to database and product distribution software. The development contractor will develop and deliver software configuration control mechanisms and procedures (with USG approval) as part of the NPOESS Ground Equipment. USG staff will oversee and manage NPOESS software configuration control.

5.1.1.4.2 Commercial-off-the-Shelf (COTS) Software Maintenance. The NPOESS system requires maintenance of COTS (commercial off-the-shelf) or contractor-modified COTS software selected for use in NPOESS C^3 Ground Equipment. Maintenance includes automatic and timely licensing and software version upgrades, as well as modification to COTS software required to ensure compatibility with USG-requested hardware upgrades.

5.2 Support Equipment

Maximum utilization shall be made of non-developmental items (NDI) or COTS items, including Original Equipment Manufacturer (OEM) data processing equipment and standard software systems. NDI or COTS hardware, including computers, communications equipment, and monitoring and testing hardware, should be furnished whenever practical. Maintenance of COTS hardware shall be guided by maintenance concepts given in 5.1.1.

5.3 C^4I/Standardization, Interoperability and Commonality

5.3.1 C^4I System Integration. The NPOESS acquisition and design shall comply with existing DoD and DOC Compatibility, Interoperability, and Integration of Command, Control, Communications, Computers, and Intelligence (C^4I) standards, where applicable. The design must address open systems environment goals and interoperability with supported C^4I systems. The NPOESS shall comply with appropriate information technology standards (DoD/DOC) applicable at the time of IOC.

5.3.2 Data Fusion Requirements. NPOESS Spacecraft will collect environmental data and transmit it to the IDP Segment which will fuse spacecraft collected data with additional environmental data available at the host location. Voice and video fusion are not currently planned. NPOESS IDP Segment will interface with Centrals' networks in compliance with applicable standards. NPOESS has no anti-jam requirements.

5.3.3 Intelligence Information Requirements. NPOESS does not directly interface with any intelligence systems and requires no input from any intelligence source or data base.

5.3.4 Joint, NATO and Coalition Forces Interface. The NPOESS design shall address considerations for joint use (DoD/Civil), NATO cross-servicing, etc. The design shall incorporate procedural and technical interfaces, and communications protocols and standards required to enable interoperability with other service, joint service and allied systems.

5.3.5 Communication and Technical Interfaces. NPOESS shall use standard data formats, interfaces, and methods to enable interoperability. Interoperability includes hardware and software compatibility with communication protocols and formats at the NPOESS to DoD system interface point. For this system this point is the IDP Segment hardware and software at the Centrals and the IDP Segment software at the field terminals. NPOESS to user community interfaces are shown in Figures 5.3-1 and 5.3-2. The NPOESS C3 architecture shall support the following links: T&C, SMD, HRD, LRD, and DRR. These Information Exchange Requirements (IERs) are detailed in Table B.

5.3.6 Joint Technical Architecture (JTA) and Defense Information Infrastructure/Common Operating Environment (DII/COE) Compliance. NPOESS should apply open-system design strategies to enable the insertion of new and emerging technologies while maintaining interoperability with existing NPOESS architecture. System software components will be consistent with DII COE and the system will be consistent with the DoD JTA specs and standards. All C4I interfaces will comply with the JTA specifications and standards. Standard components and interfaces will be used to the maximum extent possible.

The operating system at the Centrals Interface Data Processing Segment shall be DII/COE compliant. Additionally, the operating system specified to run the IDP Segment software at the field terminals shall be DII/COE compliant. Data output format from the IDP Segment (Centrals and field terminals) shall be JTA compliant to the maximum extent possible.

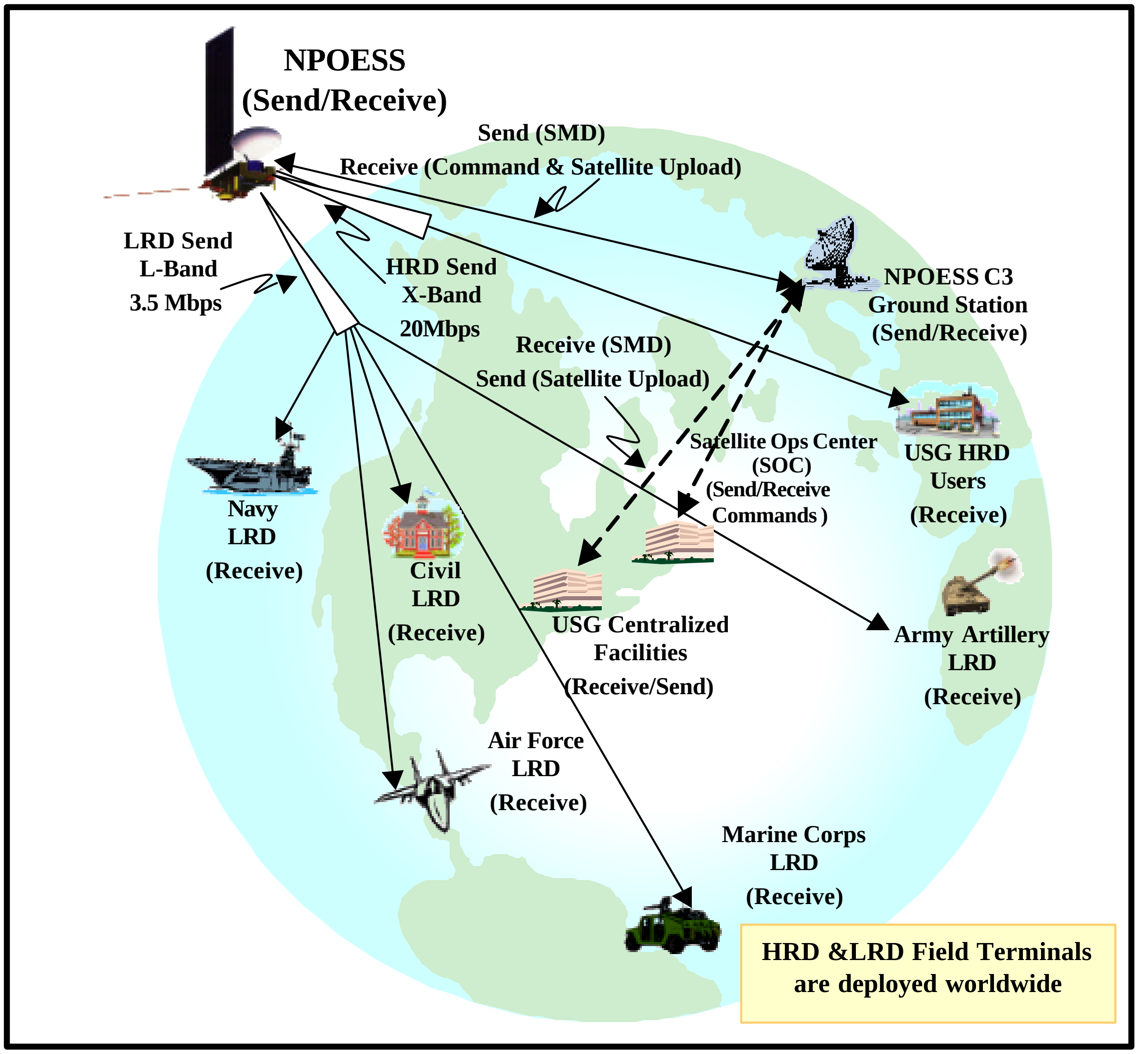

Figure 5.3-1 High-level Operational Concept Graphic (OV-1)

5.3.7 Global Command and Control System Interface. NPOESS does not directly interface with DoD systems other than weather/METOC community systems at the Centrals and weather satellite receiver field terminals.

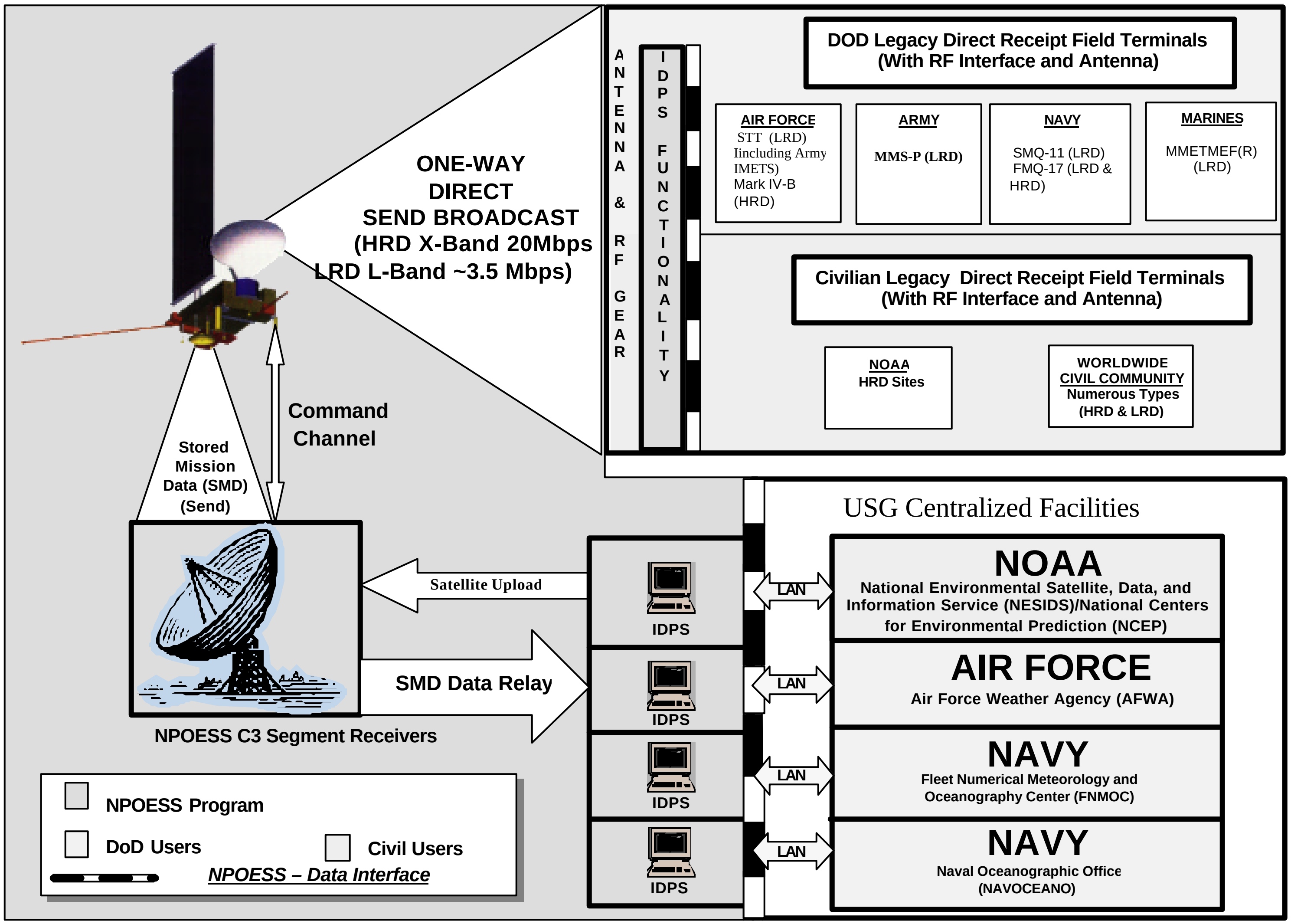

Figure 5.3-2 NPOESS System Interface Description (SV-1)

Table B - Top Level Information Exchange Requirements (IER) Matrix

1	2	3	4	5	6	7	8	9	10
IER/UJTL NUMBER	**EVENT/ ACTION**	**INFORMATION CHARCTERIZATION**	**SENDING NODE**	**RECEIVING NODE**	**CRITICAL**	**FORMAT**	**TIMELINESS**	**CLASSIFICATION**	**REMARKS**
1. SN 2.4.2 SN 2.4.2.2 ST 2.2.3 OP 2.2.3	Collect and Assess METOC Information	Environmental Data Record Processing	NPOESS Satellite	Agency owned HRD and LRD terminals	Yes	Data (CCSDS/ CGMS)	Less than 2 minutes after loss of signal for visible and infrared imagery	Unclassified	1.) NPOESS will develop IDPS software 2) Agency will provide RF gear, antennas and field terminal hardware
2. SN 2.4.2 SN 2.4.2.2 ST 2.2.3 OP 2.2.3	Collect and Assess METOC Information	Environmental Data Record Processing	NPOESS Satellite	USG Centralized Facilities	Yes	Data (CCSDS/ CGMS)	Within 90 minutes of satellite collecting data	Unclassified	NPOESS will build IDPS (hardware & software) for Centralized Facilities 2.) USG will provide LAN connection I/O from IDPS to Central data processing computer
3	Pass Ancillary METOC Data	Environmental Data Record Processing	AFEA, FNMOC, NAVOCEANO	NPOESS Interface Data Processing Segment (IDPS) at USG Centralized Facilities	Yes	Data (GRIB)	NLT 5 Min before start of EDR processing	Unclassified	USG Central processing computer will provide ancillary data to NPOESS IDPS required to process EDRs.

5.3.8 Information Assurance Requirements.

5.3.8.1 General. NPOESS is an unclassified program and does not directly interface with any classified systems. NPOESS shall have the capability to encrypt data transmission when Data Denial is directed by the National Command Authority. Decryption keys will only be distributed to direct and centralized authorized users. Data accessibility will be denied to all unauthorized users during periods of Data Denial. Data encryption will be via approved commercial means that may include, but not limited to, Public Key Infrastructure (PKI.) All satellite command uplinks will be authenticated using NSA approved encryption.

5.3.8.2. Information Integrity and Availability. Reference paragraphs 4.1.5.11.2 and 4.1.5.1.

5.3.8.3. Prevent Opportunity to Attack. Although NPOESS has no means to prevent a determined attack on its satellites, IORD Attachment 2 (Classified), addresses survivability requirements. Paragraphs 4.4.4.3 addresses resource protection requirements and paragraph 7.1 addresses anomaly resolution requirements.

5.3.8.4. Access Control. Reference paragraphs 4.4.4.1, 4.4.4.2, 4.4.4.5.1, and 4.4.4.5.4.

5.3.8.5. Detection and Responses. Referenced in IORD Attachment 2 - Survivability Requirements (Classified) and paragraph 4.4.4.5.4.

5.3.8.6. Security Domains. Reference paragraph 5.3.8.1 NPOESS is an unclassified program and does not directly interface with any classified systems.

5.3.8.7. Authentication/Confidentiality/Non-repudiation. NPOESS shall meet and maintain minimum IA Defense in Depth standards, including certification and accreditation in accordance with the DITSCAP process (e.g. DoDI 5200.40). Data encryption will be via approved commercial means that may include, but not limited to, Public Key Infrastructure (PKI.)

5.3.8.8. Confidentiality Services. Reference paragraph 5.3.8.1 NPOESS is an unclassified program and does not directly interface with any classified systems.

5.3.9 Special Energy Requirements. The design should address energy standardization and efficiency needs for both fuels and electrical power, as applicable.

5.4 Computer Resources

The NPOESS system will have an information technology upgrade strategy consistent with commercial practices.

5.4.1 Computer Resource Constraints. In general, any independent or specialized computer resources needed for logistical support requirements (*e.g.*, automated test equipment) shall be interoperable with operational NPOESS Ground Equipment computer systems in terms of architecture, language support, and communications and connectivity.

5.4.2 Unique Interface Requirements. Logistical support to the NPOESS C^3 (or IDP Segment) Ground Equipment includes the requirement to maintain appropriate operational interfaces with the IDP (or C^3) segment, including any required GFE equipment and software. Any NPOESS IDP equipment shall be deployed and integrated into the existing satellite data processing and distribution facilities. The NPOESS IDP Segment shall be maintained in a way that will not interfere with the ongoing operations.

5.4.3 Documentation. All Ground Equipment hardware and software shall be described in appropriate engineering documentation that will be maintained in USG NPOESS libraries. USG requires that all documentation be prepared according to applicable NOAA Standards. The documentation should be developed to a level to allow sustainment, upgrade, modification and reprocurement of all equipment.

Operations and Maintenance manuals for all hardware provided with the C^3 and IDP Segment Ground Equipment are required 8 weeks in advance of delivery of the associated system. One of the O & M manuals shall provide an overview of the entire NPOESS C^3 (or IDP Segment) Segment including a functional description of each major element. Manuals will be provided as defined in the following subsections and shall be written in accordance with applicable agency standards. All NPOESS Ground Equipment software, other than commercial computer manuals, shall be covered in this documentation.

An Interface Control Document (ICD) describing all electrical and data transfer media interfaces with the NPOESS C^3 and IDP Segment Segments, including links to domestic, civilian, or military communications networks, and existing facilities at the SOCs, CDAs, Centrals, and DoD field terminals, will be required. Further documentation describing the data structure and signal characteristics of all NPOESS telemetry and command data is required one-year prior to the start of Initial Operational Test and Evaluation (IOT&E).

5.5 Human Systems Integration

5.5.1 Manpower. The user will determine operations and logistics support manning required for the NPOESS with the objective of no increase in government manpower requirements.

5.5.2 Human Factors. Human factors engineering shall be applied during development of NPOESS to achieve effective human-system interfaces and minimize or eliminate system characteristics that require: extensive cognitive, sensory, or physical skills; overly-intensive training, excessive workload; reduced situations awareness; or result in frequent or critical errors. Where manual operation is necessary to achieve system performance requirements, human performance time and accuracy will be included in the determination of whether or not those system requirements have been met. Human factors engineering will comply with all requirements of the Occupational Safety and Health Administration (OSHA) and other Federal laws. Constraints peculiar to the NPOESS C3 Ground Equipment are TBD.

5.5.3 Training Concept and Goals. The requirement for NPOESS C^3 Segment and IDP Segment training is for operations and maintenance personnel to be certified as qualified to operate the hardware and software of these NPOESS Segments. Qualification will be certified by the contractor training instructors following execution of a training plan subject to USG approval. The training plan to meet this goal will cover all aspects of hardware and software needed to insure operational continuity of the NPOESS data acquisition, data quality control, and EDR processing and distribution. All operations staff are required to be fully trained before the start of IOT&E.

USG requires operational training material and instruction, and will approve all training material and course formats proposed by the NPOESS contractor. USG requires an operational database be implemented for operations staff to maintain, track and report system status.

The USG requires that a training plan be developed not later than six months prior to the scheduled delivery of the NPOESS Ground Equipment. This training plan shall be consistent with the provisions of applicable agency standards. Software maintenance and usage training will be provided in accordance with applicable agency standards.. Sufficient hardware (training simulator systems) shall be provided to ensure the system operators and maintainers can be trained to properly perform their mission. Upon completion of any contractor-developed course, copies of training materials (instructor lesson plans, student study guides, overheads, *etc.*) will be provided to the appropriate government agency for use in developing follow-on sustainment training.

5.6 Other Logistics and Facilities Considerations

5.6.1 Provisioning Strategy/Spares Concept. The NPOESS Ground Equipment requires spare parts to ensure overall NPOESS system reliability and data availability. Initial supplies, to the quantities specified, shall be provided by the contractor at the start of IOT&E. The USG, together with the contractor during IOT&E, will analyze parts usage and correct these specifications, as dictated by experience. Following FOC, the USG will stock necessary spare parts. In time of international crisis or heightened tensions, the number of parts advance-stocked will be increased to the number expected to be required during a one year period.

5.6.2 Support Systems/Site Preparation. Site preparation at C^3 sites, SOCs and IDP Centrals will be the responsibility of the USG and will provide for building modifications, uninterruptible power system, heating, ventilation, and air conditioning (HVAC) and other attributes of the physical plant. The contractor shall provide a preliminary estimate of requirements for space (both square footage of floor space and volumetric - especially required are volume and dimensions below floor and head room above raised floor), and power requirements (power factor, peak load, *etc.*).

5.6.3 Special Equipment Supplied to the USG. The C^3 Segment Contractor will be required to provide a high-fidelity spacecraft emulator containing, if applicable, a computer identical in performance to the spacecraft on-board computer. In addition, the emulator will simulate with the highest practical fidelity, all instruments and subsystems and will faithfully reproduce the spacecraft reaction to any commands or sequence of commands. The spacecraft emulator will not be required to provide high-fidelity emulation of scientific data, but it will be required to provide data at the instrument output ports which resembles true scientific data from a spacecraft housekeeping analysis perspective.

5.6.4 Systems Integration and Acceptance Tests. On-site tests of the NPOESS Ground Equipment is required for system acceptance. Integration and Acceptance tests of NPOESS Ground Equipment hardware and software will be conducted after installation of equipment at the Centrals, SOCs, CDAs, and, if applicable, USB compatible AFSCN stations. These tests will be conducted in accordance with contractor provided/USG approved test plans and procedures, using USG provided personnel in operational capacities. Tests will parallel live operations and may use live, recorded or simulated telemetry inputs, as appropriate. Tests shall be designed to ensure no loss of operational data and will result in no impact to ongoing operations. Test plans will incorporate procedures to disengage the test system in order to reestablish operations.

5.6.5 Field Terminals. DoD and DOC require equipment to acquire NPOESS data in real time. NPOESS equipment that receives the HRD raw data shall generate RDRs, SDRs, and EDRs required for local field site use as specified in Table C. This equipment shall have the capability to store RDRs, SDRs, and EDRs until the data can be delivered to the NPOESS equipment/Field Terminal interface. Other equipment shall be capable of receiving the LRD data and providing it to the local field terminal displays.

DOC and DoD will, as required, operate those field terminals that will receive NPOESS data. A Memorandum of Agreement (MOA) drafted by the IPO and JARG details roles and responsibilities as well as architecture and maintenance strategies for the IDP Segment equipment for DoD and DOC field terminals. The MOA was signed by the military service and NOAA representatives to the NPOESS Senior Users' Advisory Group (SUAG) for the DoD and DOC. This document discusses the acquisition and maintenance of the NPOESS specified equipment for DoD and DOC field terminals, and specifies provision of interface control documentation for the NPOESS software and specified equipment as it applies to field terminals. Details of the field terminals, themselves, are not discussed.

5.6.5.1 Field Terminal Modifications. The NPOESS program shall develop the operational software needed to process NPOESS data in DoD and DOC field terminals and provide a set of specifications for the field terminal hardware required to run the software. The intent is to enable ingest and processing of NPOESS and legacy real-time data. These modifications should cause no degradation in existing terminal capabilities. Software commonality should exist between the IDP Segment and the field terminals to the maximum extent possible. The NPOESS program will develop field terminal prototypes to demonstrate capability and provide a minimal set of specifications to facilitate users' field terminal acquisition programs.

TABLE C – NPOESS Environmental Data Records (EDR)/Raw Data Record (RDR) Matrix

		Centrals' Latency Requirements		Field Terminal Requirements				
				High Rate Data Terminal (20Mbps)				Low Rate Data Terminal (3.5 Mbps)
IORD Para		Objective (mins)	Threshold (mins)	Navy	DOC	AF/Army	Aggregate	
Key EDRs [6]								
4.1.6.1.1	Atmospheric Vertical Moisture Profile	15	156	R/E	R/E	R/E	R/E	T-3
4.1.6.1.2	Atmospheric Vertical Temperature Profile	15	156	R/E	R/E	R/E	R/E	T-2
4.1.6.1.3	Global Sea Surface Winds	15	90	R/E	R/E	R/E	R/E	T-4
4.1.6.1.4	Imagery	15	90	R/E	R/E	R/E	R/E	T-1
4.1.6.1.5	Sea Surface Temperature	15	90	R/E	R/E	R/E	R/E	T-8
4.1.6.1.6	Soil Moisture	30	90	R/E	R/E	R/E	R/E	O
Atmospheric Parameters [9]								
4.1.6.2.1	Aerosol Optical Thickness	15	90	R/E	R/E	R/E	R/E	O
4.1.6.2.2	Aerosol Particle Size	N/A	N/A	R/E	R/E	R/E	R/E	
4.1.6.2.3	Aerosol Refractive Index/Single-Scattering Albedo and Shape	N/A	N/A		R/E	R/E	R/E	
4.1.6.2.4	Ozone Total Column/Profile	15	120		R/E	R/E	R/E	
4.1.6.2.5	Precipitable Water/Integrated Water Vapor	15	90	R/E	R/E	R/E	R/E	O
4.1.6.2.6	Precipitation Type/Rate	15	90	R/E	R/E	R/E	R/E	O
4.1.6.2.7	Pressure (surface/profile)	15	156	R/E	R/E	R/E	R/E	T-7
4.1.6.2.8	Suspended Matter	15	90	R/E	R/E	R/E	R/E	O
4.1.6.2.9	Total Water Content	15	90	R/E	R/E	R/E	R/E	O
Cloud EDRs [10]								
4.1.6.3.1	Cloud Base Height	15	90	R/E	R/E	R/E	R/E	T-5
4.1.6.3.2	Cloud Cover/Layers	15	90	R/E	R/E	R/E	R/E	T-6
4.1.6.3.3	Cloud Particle Size Distribution	N/A	N/A			R/E	R/E	
4.1.6.3.4	Cloud Effective Particle Size	15	90		R/E	R/E	R/E	O
4.1.6.3.5	Cloud Ice Water Path	15	156		R/E	R/E	R/E	
4.1.6.3.6	Cloud Liquid Water	15	90	R/E	R/E	R/E	R/E	O
4.1.6.3.7	Cloud Optical Thickness	15	90		R/E	R/E	R/E	O
4.1.6.3.8	Cloud Top Height	15	90	R/E	R/E	R/E	R/E	O
4.1.6.3.9	Cloud Top Pressure	15	90	R/E	R/E	R/E	R/E	
4.1.6.3.10	Cloud Top Temperature	15	90	R/E	R/E	R/E	R/E	O
Earth Radiation Budget EDRs [6]								
4.1.6.4.1	Albedo (Surface)	60	150	R/E	R/E	R/E	R/E	O
4.1.6.4.2	Downward Longwave Radiation (Surface)	60	150					
4.1.6.4.3	Downward Shortwave Radiation (Surface)	60	150					
4.1.6.4.4	Net Solar Radiation at Top of Atmosphere	60	150					
4.1.6.4.5	Solar Irradiance	N/A	N/A					
4.1.6.4.6	Outgoing Longwave Radiation (ToA)	60	150					
Land EDRs [4]								
4.1.6.5.1	Land Surface Temperature	15	90	R/E	R/E	R/E	R/E	O
4.1.6.5.2	Vegetation Index	15	90	R/E	R/E	R/E	R/E	
4.1.6.5.3	Snow Cover/Depth	15	90	R/E	R/E	R/E	R/E	O
4.1.6.5.4	Surface Type	15	90			R/E	R/E	
Ocean/Water EDRs [7]								
4.1.6.6.3	Net Heat Flux	360	1440	R/E		R/E	R/E	
4.1.6.6.4	Sea Ice Characterization	15	480	R/E	R/E	R/E	R/E	
4.1.6.6.5	Ice Surface Temperature	15	90	R/E	R/E	R/E	R/E	
4.1.6.6.6	Ocean Color			R/E	R/E	R/E	R/E	
	- Operational	60	180	R/E	R/E	R/E	R/E	
	- Science Quality	1440	2880	R	R	R	R	
4.1.6.6.7	Sea Surface Height/Topography				R/E	R/E	R/E	
	- Mesoscale	180	1440		R/E	R/E	R/E	
	- Basin Scale	2880	4320		R/E	R/E	R/E	
	- Global Scale	2 mo	3 mo		R/E	R/E	R/E	
4.1.6.6.8	Ocean Wave Characteristics/Significant Wave Height	15	120	R/E	R/E	R/E	R/E	O
4.1.6.6.9	Global Sea Surface Wind Stress	15	90	R/E	R/E	R/E	R/E	
Space Environmental EDRs [13]								
4.1.6.7.1	Auroral Boundary	15	90			R/E	R/E	
4.1.6.7.2	Auroral Energy Deposition	15	90			R/E	R/E	
4.1.6.7.3	Aurorol Imagery	15	90			R/E	R/E	
4.1.6.7.4	Electric Field	15	90			R/E	R/E	
4.1.6.7.5	Electron Density Profile	15	90			R/E	R/E	
4.1.6.7.6	Geomagnetic Field	15	90			R/E	R/E	
4.1.6.7.7	*In situ* Plasma Fluctuations	15	90			R/E	R/E	
4.1.6.7.8	*In situ* Plasma Temperatures	15	90			R/E	R/E	
4.1.6.7.9	Ionospheric Scintillation	15	90			R/E	R/E	
4.1.6.7.10	Neutral Density Profile	15	90			R/E	R/E	
4.1.6.7.11	Medium Energy Charged Particles	15	90			R/E	R/E	
4.1.6.7.12	Energetic Ions	15	90			R/E	R/E	
4.1.6.7.13	Supra-Thermal through Auroral Energy Particles	15	90			R/E	R/E	

- – Subordinate EDRs mo – months E - Just the EDR Required R/E - EDR and RDRs that went into developing EDR required
T-n – Threshold. Mandatory for data to produce the EDR to be in the LRD downlink. "n" is the data bandwidth priority with n=1 being highest priority.
O – Objective. Desirable for data to produce the EDRs to be in the downlink but not at the expense of bandwidth for the threshold EDRs. No priority.

Table C describes the desired time latency (objective and threshold) as determined by users. For Field Terminal Requirements, an "E" indicates that only the EDR is required by the user. An "R/E" indicates that both the EDR and RDRs (that were included during EDR development) are required by the user.

5.6.5.2 Field Terminal Maintenance. Field level (operator) maintenance of the NPOESS software residing in a field terminal is required and should be consistent, to the maximum extent possible, with customary field terminal operations and maintenance concepts. Appropriate software maintenance training shall be provided by the USG. Arrangements for depot level maintenance of the NPOESS field terminal hardware and software will be made in accordance with an MOA developed by the IPO and JARG that details specifically who is responsible for specific field terminal maintenance and upgrade functions. The MOA will be signed by the NPOESS Senior Users' Advisory Group (SUAG).

5.6.5.3 Field Terminal Integration and Acceptance Tests. Integration and Acceptance tests of all NPOESS software shall be conducted after installation of equipment at selected field terminals. These tests will be conducted in accordance with contractor provided, USG approved, test plans and procedures, using USG provided personnel in operational capacities.

5.7 Transportation and Basing

Centrals and the SOCs consist of fixed installations and are not subject to movement. Requirements for field terminals are to be specified (TBS) by the USG.

5.8 Geospatial Information and Services

C^3 Segment requirements for site surveys and antenna alignment surveys shall be performed as needed.

Hydrologic and cartographic material, digital topographic data or geodetic data support required to support this program will be standard products from the National Imagery and Mapping Agency.

5.9 Natural Environmental Support

The NPOESS requires normal weather, to include space weather, forecast support during launch activities. While on orbit, NPOESS requires normal space environmental support to aid in analyzing communication and satellite anomalies.

6.0 Force Structure

The NPOESS IPO is required to provide enough satellites to meet IORD requirements for at least 10 years. Initial estimates indicate that 6 satellites filling 3 orbital planes will satisfy threshold stated requirements. Additionally, NPOESS will provide ground processing equipment at four centrals to produce EDRs per the stated requirements. A primary and a backup Satellite Operations Center will be implemented at dispersed geographic locations for satellite constellation management. Additionally, numerous tactical terminals will be available to tri-agency members supporting in-field requirements.

7.0 Schedule

The NPOESS shall follow an incremental acquisition, development, and deployment strategy to support a mission life cycle of 10 years. Key milestones and schedule issues are discussed below.

7.1 Initial Operational Capability (IOC) Criteria

The NPOESS program director will declare IOC has been met when: NPOESS satellites are operational in two different orbital planes; sufficient C^3 and mission data recovery resources are available to allow all mission data to be processed at all Centrals and 50 percent of field terminals; sufficient crews are trained to allow 24 hours/day, 365 days/year operations at the primary SOC, and to allow backup operations as needed; sufficient sustaining engineering resources are in place to allow for anomaly resolution, for example; sufficient logistics resources are in place to support C^3, data recovery, and the IDP segment; and approval to operate at Schriever AFB is received.

7.2 First Need Date

NPOESS is required to back up NOAA N’ or DMSP F20. “Back up” is defined as having the ability to place an operational satellite on orbit (supported by necessary C3S and IDP Segment infrastructure) no later than 180 days after the planned launch of NOAA N’ or DMSP F20.

7.3 Full Operational Capability (FOC) Criteria

The NPOESS program director will declare that FOC has been met when: IORD KPP requirements are met, including revisit criteria; sufficient C^3 and mission data recovery resources are available; sufficient crews are trained; sufficient logistics resources are in place to support C^3, data recovery, and the IDP segment.

8.0 Program Affordability

The NPOESS program was originated by a Presidential Decision Directive (PDD/NSTC-2) in May 1994 which directed the convergence of national polar-orbiting environmental satellite programs. The National Performance Review of September 1993 established a cost avoidance goal of $1.3B life cycle cost from the then planned upgrade programs, POES OPQ and DMSP Block 6. This cost savings was the basis for the creation of the NPOESS program and is therefore a threshold requirement. The Optimized Convergence program established during Phase I resulted in a cost avoidance of $1.8B. As an objective, continued implementation of CAIV will improve from or maintain the estimated cost avoidance of the Optimized Convergence program. This cost avoidance will be revalidated at the Milestone decision and will become the basis for the Acquisition Program Baseline (APB) for the remainder of the program.

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Appendix A

References

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Appendix B

Distribution List

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Appendix C

List of IORD Supporting Analyses

NPOESS, Final Phase 0 Cost and Operational Benefits Requirements Analysis Report (COBRA), June 12, 1996

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Appendix **D**

Capstone Requirements Documents(CRDs)

Applicable IORD KPP/Requirements Cross Walk/Linkage

IDM CRD KPP	Supporting NPOESS IORD KPP/Linkage
INTEROPERABILITY: Satisfy 100% of critical IERs to the threshold level **(Threshold, KPP).** Satisfy 100% of IERs to the objective level of the attributes (**Objective KPP**).	All top-level IERs (Table B) will be satisfied to the standards specified in the threshold (T) and objective (O) values. **Threshold:** 100% of top-level IERs designated **critical. Objective:** 100% of top-level IERs.
INFORMATION INTEGRITY: IDM will provide a means to ensure that information integrity will be maintained during delivery at the 99.99% (**Threshold, KPP**) and 99.999% (**Objective, KPP**) level.	4.1.5.11, States "NPOESS data communications links shall maintain and guarantee during transport the integrity of all information elements exchanged; information integrity shall be at least 99.99%.

GIG CRD KPP	Supporting NPOESS IORD KPP/Linkage
INTERROPERABILITY: Systems shall satisfy all critical IER attributes at the threshold level (**Threshold, KPP**) and satisfy all critical IER attributes to the objective level (**Objective, KPP**).	All top-level IERs (Table B) will be satisfied to the standards specified in the threshold (T) and objective (O) values. **Threshold:** 100% of top-level IERs designated **critical. Objective:** 100% of top-level IERs.
INFORMATION INTEGRITY: Systems shall maintain and guarantee during transport the integrity of all information elements exchanged throughout the GIG to enable user confidence; information integrity shall be 99.99 % (**Threshold, KPP**) and 99.999 % (**Objective, KPP**).	4.1.5.11 ,States "NPOESS data communications links shall maintain and guarantee during transport the integrity of all information elements exchanged; information integrity shall be at least 99.99%.
INFORMATION ASSURANCE: Systems shall meet and maintain minimum IA Defense in Depth standards, including certification and accreditation IAW the DITSCAP process (e.g., *CJCSI 6510.01C, DoDI 5200.40*) (**Threshold, KPP**).	5.3.8.7. Authentication/Confidentiality/Non-repudiation. NPOESS shall meet and maintain minimum IA Defense in Depth standards, including certification and accreditation in accordance with the DITSCAP process (e.g. DoDI 5200.40.)

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Appendix E
Information Exchange Requirements (IER) Matrix

IER/UJTL NUMBER	EVENT/ ACTION	INFORMATION CHARCTERIZA-TION	SENDING NODE	RECEIVING NODE	CRITI-CAL	FORMAT	TIMELINESS	CLASSIFICA-TION	REMARKS
1. SN 2.4.2 SN 2.4.2.2 ST 2.2.3 OP 2.2.3	Collect and Assess METOC Information	Environmental Data Record Processing	NPOESS Satellite	Agency owned HRD and LRD terminals	Yes	Data (CCSDS/ CGMS)	Less than 2 minutes after loss of signal for visible and infrared imagery	Unclassified	1.) NPOESS will develop IDPS software 2) Agency will provide RF gear, antennas and field terminal hardware
2. SN 2.4.2 SN 2.4.2.2 ST 2.2.3 OP 2.2.3	Collect and Assess METOC Information	Environmental Data Record Processing	NPOESS Satellite	USG Centralized Facilities	Yes	Data (CCSDS/ CGMS)	Within 90 minutes of satellite collecting data	Unclassified	NPOESS will build IDPS (hardware & software) for Centralized Facilities 2.) USG will provide LAN connection I/O from IDPS to Central data processing computer
3	Pass Ancillary METOC Data	Environmental Data Record Processing	AFEA, FNMOC, NAVOCEANO	NPOESS Interface Data Processing Segment (IDPS) at USG Centralized Facilities	Yes	Data (GRIB)	NLT 5 Min before start of EDR processing	Unclassified	USG Central processing computer will provide ancillary data to NPOESS IDPS required to process EDRs.

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Glossary Part I

ACRONYMS AND ABBREVIATIONS

	A	
AF		Air Force
AFWA		Air Force Weather Agency
AFI		Air Force Instruction
AFM		Army Field Manual
AFSCN		Air Force Satellite Control Network
AFSPC		Air Force Space Command
AGE		Aerospace Ground Equipment
AN/UMQ-13		Mark IVB Field Terminal
APT		Automatic Picture Transmission
atm-cm		Atmosphere-centimeter
	B	
BIT		Built-In-Test
BITE		Built-In-Test-Equipment
	C	
CDA		Command and Data Acquisition
CDR		Critical Design Review
Centrals		Central Weather Data Processing Facilities
cm		Centimeters
$cm\ m^{-2}$		Centimeters Per Square Meter
CH_4		Methane
CO		Carbon Monoxide
CO		Colorado
CO_2		Carbon Dioxide
COMPUSEC		Computer Security
COMSEC		Communications Security
COTS		Commercial-Off-The-Shelf
C^3		Command, Control, and Communications
C^3I		Command, Control, Communications, and Intelligence
C^4I		Command, Control, Communications, Computers, and Intelligence
C^4ISR		Command Control, Communications, Computers, Intelligence, Surveillance and Reconissance

D

DMSP	Defense Meteorological Satellite Program
DOC	Department of Commerce
DoD	Department of Defense
DRR	Data Routing and Retrieval

E

E	Ionosphere Region Designator
ECCM	Electronic Counter-Counter Measures
EDR	Environmental Data Record
EO	Electro-Optical
ESA	European Space Agency
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
eV	Electron-volts

F

FM	Field Manual
FMH	Federal Meteorological Handbook
FMQ-17	AN/FMQ-17 Navy Tactical Terminal (Ashore)
FNMOC	Fleet Numerical Meteorology and Oceanography Center
FOC	Full Operational Capability
FT	Field Terminal

G

GeV	Giga Electron-volts
GFE	Government Furnished Equipment
GHz	Giga-Hertz
$g\ m^{-3}$	Grams Per Cubic Meter
GPS	Global Positioning System

H

HCS	Horizontal Cell Size
HQ	Headquarters
HRPT	High Resolution Picture Transmission
HSI	Human Systems Integration

I

IAW	In Accordance With
IDP	Interface Data Processor
ILS	Integrated Logistics Support

IJPS	Initial Joint Polar System
INFOSEC	Information Security
IOC	Initial Operating Capability
IORD	Integrated Operational Requirements Document
IOT&E	Initial Operational Test and Evaluation
IPO	Integrated Program Office
IR	Infrared

K

K	Kelvin
kbps	Kilobits Per Second
keV	Kilo Electron-volts
kg m^{-2}	Kilogram Per Meter Squared
km	Kilometer

L

LRPT	Low Resolution Picture Transmission
LRU	Line Replaceable Unit
LST	Local Solar Time
LTAN	Local Time Ascending Node

M

m	Meters
m^2	Square Meters
Mark III	Model AN/TMQ-37 TACTERM
Mark IV	Model AN/TMQ-35 TACTERM
Mark IVB	Model AN/UMQ-13 TACTERM
MB	Megabytes
Mb	Megabits
mb	Millibar
Mbps	Megabits-per-second
MD	Maryland
METMF(R)	USMC Tacterm
MeV	Mega-electron Volts
mg m^{-3}	Milligrams Per Cubic Meter
mg l^{-1}	Milligrams Per Liter
MHz	Mega-hertz
MLV	Medium Launch Vehicle
mm	Millimeter

mm hr^{-1}	Millimeters Per Hour
mm m^{-1}	Millimeters Per Meter
mm m^{-2}	Millimeters Per Square Meter
MNS	Mission Need Statement
MTBCF	Mean Time Between Critical Failure
MTBDE	Mean Time Between Downing Events
MTTR	Mean Time To Repair
MTTRF	Mean Time To Restore Function
m s^{-1}	Meters Per Second

N

N	Newtons
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NAVOCEANO	Naval Oceanographic Office
NBC	Nuclear, Biological, and Chemical
NDI	Non-Developmental Item
NESDIS	National Environmental Satellite, Data, and Information Service
NF	NOFORN (Not Releasable to Foreign Nationals)
N m^{-2}	Newtons per Square Meter
nm	Nanometer
NOAA	National Oceanic and Atmospheric Administration
NORAD	North American Aerospace Defense Command
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NSA	National Security Agency
nT	Nanotesla
NWS	National Weather Service

O

OPSEC	Operations Security
OR	Operational Requirement
ORD	Operational Requirements Document
OT&E	Operational Test and Evaluation

P

P3I	Pre-Planned Product Improvement
P4I	Pre-Planned Product and Process Improvement
PGM	Precision Guided Munitions
POES	Polar-orbiting Operational Environmental Satellite

ppmv	Parts per million by volume
PSE	Peculiar Support Equipment
PTF	Payload Test Facility
R	
RCM	Requirements Correlation Matrix
RDR	Raw Data Record
RF	Radio Frequency
RH	Relative Humidity
RMA	Reliability, Maintainability, and Availability
S	
S	Secret
S	seconds
S/C	Spacecraft
SCA	Satellite Control Authority
SDR	Sensor Data Record
sfc	Surface
SMC	Space and Missile Systems Center
SMOP	Satellite Measurement of Oceanographic Parameters
SMQ-11	USN Tactical Terminal
SOC	Satellite Operations Center
SON	Statement of Need
SOPS	Space Operations Squadron
SST	Sea Surface Temperature
STAR	System Threat Assessment Report
ster	steradian
STRATCOM	Strategic Command
STT	Small Tactical Terminal
T	
T/P	Topex/Poseidon
TACTERM	Tactical Terminal
TBD	To Be Described/To Be Determined
TEC	Total Electron Content
TESS	Tactical Environmental Satellite System
TO	Technical Order
TOA	Top Of Atmosphere

U

U	Unclassified
UHF	Ultra High Frequency
US	United States
USA	United States Army
USAF	United States Air Force
USB	Universal S-band
USCG	United States Coast Guard
USG	United States Government
USMC	United States Marine Corps
USN	United States Navy
USSPACECOM	United States Space Command
UV	Ultraviolet

V

V	Vertical

W

W	Watts
W m^{-2}	Watts per square meter
WX	Weather

Glossary Part II

TERMS AND DEFINITIONS

Absolute humidity

The mass of water vapor per unit volume of moist air expressed in grams per cubic centimeter.

Atmosphere-centimeter (atm-cm)

Read as atmosphere-centimeter, atm-cm denotes the amount of a gas in a vertical column from the earth's' surface to space. It is the thickness of the slab of gas, in centimeters, if all the gas were concentrated in a layer at a pressure of atmosphere.

C^3 Segment

The system segment responsible for Command, Control, and Communications.

Centrals

Primary processing centers that use NPOESS RDRs and/or EDRs, and other data to produce environmental products for their customers. The processing, archiving, and dissemination of these data is their responsibility. For NPOESS, the following are Centrals: Air Force Weather Agency (AFWA), Fleet Numerical Meteorology and Oceanography Center (FNMOC), the Naval Oceanographic Office (NAVOCEANO), and National Environmental Satellite, Data, and Information Service (NESDIS)/National Centers for Environmental Prediction (NCEP).

Closest Point to Shore *(For Sea Surface Height EDR*)

Distance from a coastline with smooth topography along a perpendicularly intersecting ground track. Closest point is the distance at which 65% of the altimeter data is in fine track mode for satellite passes approaching land and 50% of the altimeter data is in fine track mode for satellite passes receding from land. For coastal values, radiometric corrections are not required within 40 km of shore.

Cloud

An aggregate of minute non-precipitating water and/or ice particles in the atmosphere above the earth's surface.

Cloud Cover

The fraction of a given area overlaid in the local normal direction by clouds. It is the portion of the earth's horizontal surface masked by the vertical projection of clouds.

Cloud Type

The classification of clouds into the types given in Tables 3-19 and 3-20 of the Federal Meteorological Handbook 1B.

Coastal

Coastal coverage refers to the areal extent consistent with the U.S. Exclusive Economic Zones (EEZ) which extend 370 km from shore. Coastal coverage shall entail roughly 300 km swath coverage, but pertains to all coasts worldwide to support civil and military observations.

Common Support Equipment (CSE)

Support equipment capable of common use by various systems throughout DoD, NOAA, and NASA, as applicable.

Communications Security (COMSEC)

Measures and controls taken to deny unauthorized persons information derived from telecommunications and ensure the authenticity of such telecommunications. NOTE: Communications security includes cryptosecurity, transmission security, emission security, and physical security of COMSEC material.

Computer Security (COMPUSEC)

Measures and controls that ensure confidentiality, integrity, and availability of the information processes and stored by a computer.

Critical Failure

Any fault, failure or malfunction which results in the loss of the system's ability to provide any key parameter.

Critical Design Review (CDR)

A technical review of the detail design of each configuration item of a system to (1) determine that the detail design of the configuration item under review satisfies the performance and engineering specialty requirements, (2) establish the detail design compatibility among the configuration item and other items of equipment, facilities, computer software and personnel, (3) assess configuration item risk areas (on a technical, cost, and schedule basis), (4) assess the results of the producibility analysis conducted on system hardware, and (5) review the preliminary hardware product specifications. For computer software configuration items, this review will focus on the determination of the acceptability of the detailed design, performance, and test characteristics of the design solution, and on the adequacy or the operation and support documents.

Electronic Counter-Countermeasures (ECCM)

Measures taken to counter electronic warfare susceptibility and vulnerability of a specific system.

Environmental Data

"Environmental data" as used in this IORD is also termed "mission data" and refers to all data: atmospheric, oceanographic, terrestrial, space environmental and climatic, being sensed and collected by the spacecraft.

Environmental Data Record (EDR)

Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to geophysical parameters (including ancillary parameters, e.g., cloud clear radiation, etc.).

Equatorial Track Spacing *(For Sea Surface Height EDR*)

The maximum distance along the equator between adjacent ascending sea surface height profiles after the Exact Repeat Period.

Exact Repeat Period *(For Sea Surface Height EDR)*

Same as Refresh (time period for the ground trace to repeat), with the additional specification that the satellite nadir point must be no further than 1 km from the nominal reference ground track at all times.

Field Terminals

Field Terminals include the various DoD and DOC receivers used by deployed/remote units to obtain environmental data in real time.

First-year ice

Sea ice of not more than one winter’s growth, developing from young ice; thickness 30 cm- 2 m. May be subdivided into thin first-year ice / white ice, medium first-year and thick first-year ice.

Grey ice

Young ice 10-15 cm thick. Less elastic than nilas and breaks on swells. Usually rafts under pressure.

Grey-white ice

Young ice 15-30 cm thick. Under pressure more likely to ridge than to raft.

Horizontal Cell Size

For a parameter which is an estimate of the uniform spatial average of an environmental parameter over a square region of the earth's surface or within a square layer of the atmosphere, the side length of this square region or layer. (For a parameter which is an estimate of an environmental parameter at a point, the horizontal cell size is defined to be zero.) For a reported parameter not of this type but which is defined for a square region of the earth's surface or a square layer of the atmosphere (e.g., cloud cover, ice concentration, etc.), the side length of this square region.

Horizontal Reporting Interval

The spacing between nearest neighbor points in the horizontal direction at which an environmental parameter is estimated and reported. For atmospheric profiles, the horizontal reporting interval applies to the lowest altitude samples.

Horizontal Spatial Resolution

For a scanning imager on a space-based platform, a specified band, and a specified nadir angle, one half of the wavelength corresponding to the earth surface spatial frequency at which the end-to-end system modulation transfer function (MTF) equals 0.5 on the in-track spatial frequency axis or cross-track spatial frequency axis, whichever is greater. The in-track (cross-track) spatial frequency is the earth surface spatial frequency associated with the in-track (cross-track) direction. (See definition of Modulation Transfer Function.)

Horizontal Wind Vector Accuracy

The wind speed error is $[[W_m]-[W_t]]$ where W_m is the measured velocity and W_t is the true velocity. The wind direction error is the angular difference between the directions of each component.

Ice free

No ice present. If ice of any kind is present, this term should not be used.

Imagery

Two dimensional array of numbers, in digital format, each representing the brightness of a small elemental area.

Information Exchange Requirements (IER)

Identify the elements of war-fighter information used in support of a particular activity and between any two activities.

Information Systems Security (INFOSEC)

The protection of information systems against unauthorized access to or modification of information, whether in storage, processing or transit, and against the denial of service to authorized users or the provision of service to unauthorized users, including those measures necessary to detect, document, and counter such threats.

Interface Data Processor (IDP) Segment (

The NPOESS ground processing capability located at the Centrals. The IDP Segment receives RDRs from the Space or C^3 segment, temporarily stores RDRs, converts RDRs into EDRs (at DoD sites) then pushes all required data into the Central's computers. Field Terminal data processing will perform a subset of the functions of the Centrals IDP Segment as necessary to meet global user requirements.

Interoperability

The condition among communications-electronics systems or items of communications-electronics when information or services can be exchanged directly and satisfactorily between them and/or their users.

In-Track Resolution

Resolution of in-situ measurements along the orbital path, determined by sampling frequency.

Key Parameter

A parameter so significant that failure to meet the threshold is cause for the system to be reevaluated or the program to be reassessed or terminated. These parameters are to be included in the Acquisition Program Baseline.

Latency (Data Latency)

The period from the time of observation of all requisite data by the satellite until the EDR produced by that data is available at the IDP Segment/Central interface.

Leads

Any fracture or passageway through sea ice which is navigable by surface vessels.

Line Replaceable Unit

The smallest unit that can be removed and replaced without cutting or desoldering connections.

Long term stability

The maximum excursion of the short-term average measured value of a parameter under identical conditions over the mission duration. The short-term average is the average of a sufficient number of successive measurements of the parameter under identical conditions such that the random error is negligible relative to the systematic error. The time duration associated with the short-term mean must be long enough to average out noise, but short enough so that meaningful trend analysis can be done over the NPOESS life cycle.

Mapping Uncertainty

The maximum permissible error in geographic location of the measured data.

Mean Mission Duration

The integral of the reliability distribution R(t) evaluated from time (t) equals zero until 84 months. R(t) shall include the effect of all wearout items on the spacecraft.

Mean Time Between Critical Failures

The total amount of mission time divided by the total number of critical failures during a stated series of missions.

Mean Time To Repair

The sum of corrective maintenance items at any specific level of repair divided by the total number of failures within an item repaired at that level during a particular interval under stated conditions.

Measurement Accuracy

The systematic error, as specified by the difference between a measured or derived parameter and its true value, in the absence of random errors.

Measurement Accuracy *(For Sea Surface Height EDR*)

Based on an average over the Nadir Resolution cell. Accuracy includes radial orbit determination as well as measured range corrections (wet troposphere, ionosphere) and model-based corrections (dry troposphere, sea state bias). The required accuracy and timeliness for Coastal/Mesoscale may be obtained by high-pass filtering the sea height profiles to remove radial orbit error, which has scales greater than 10,000 km. Note that the sea surface height data will be used to derive tidal constituent amplitudes/phases as well as to observe semiannual, annual, and interannual ocean signals. Consideration must therefore be given to the temporal sampling interval as it relates to tidal aliasing. See “On the choice of orbits for an altimetric satellite to study ocean circulation and the tides”, J. Geophys. Res., 92, 11693-11707, 1987.

Measurement Precision

The uncertainty in a measured or derived parameter due only to random errors, specified as the standard deviation of a parameter.

Measurement Precision *(For Sea Surface Height EDR)*

The standard deviation from a linear fit to data at the Horizontal Reporting Interval within the Nadir Resolution cell. Precision does not include measured range corrections (wet troposphere, ionosphere), model-based corrections (dry troposphere, sea state bias), or radial orbit determination.

Measurement Range

Parameter range over which measurement accuracy and precision shall be maintained.

Measurement Uncertainty

The root-mean-square (RMS) of the measurement errors for an estimated parameter.

Medium First- year Ice

First-year ice with a thickness of 70-120 cm.

Mission Sensors

Any sensor on the spacecraft directly used to satisfy any of the EDR requirements.

Modulation Transfer Function (MTF)

The magnitude of the Fourier transform of the end-to-end system point spread function (PSF). The MTF is a function of two spatial frequencies associated with two orthogonal spatial directions, and is equal to one at the origin by virtue of the normalization condition on the PSF.

Moisture Profiles

Relative and absolute humidity - the mass of water vapor per unit volume of moist air.

Multi-year Ice

Old ice up to 3 m or more thick which has survived at least two summers' melt. Hummocks smoother than second-year ice, and the ice is almost salt free. Color, where bare, is usually blue. Melt pattern consists of large interconnecting irregular puddles and a well-developed drainage system.

Nephanalysis

Analysis of cloud cover in terms of type and amount.

Nilas

A thin elastic crust of ice, easily bending on waves and swell under pressure, thrusting in a pattern of interlocking “fingers”. Has a matt surface and is up to 10 cm in thickness.

Objective

An operationally significant increment above the threshold.

Operations Security (OPSEC)

Actions taken or plans developed to protect information, classified or unclassified, which could reveal system plans, procedures, or missions.

Parts per million by volume (ppmv)

Read as parts per million by volume, ppmv denotes volume mixing ratio, specifically the amount of gas in a sample of "air" under standard temperature and pressure. This is the volume of gas in a volume of air.

Payload

Mission sensors and on-board processor.

Peculiar Support Equipment (PSE)

Also called "unique". Support equipment especially designed for use with a specific system and usable only on that system.

Personnel Security

Procedures established to ensure that all personnel who have access to sensitive information have the required authority, as well as appropriate clearances, and the need-to-know for the information.

Preceptible Water

The total amount of water vapor contained in a vertical column of the atmosphere. Also referred to as Integrated Water Vapor.

Preventive Maintenance

Maintenance undertaken in advance of a failure to eliminate or avoid conditions anticipated to eventually lead to failure, sometimes referred to as recurring maintenance, routine maintenance or scheduled maintenance.

Raw Data Record (RDR)

Full resolution digital sensor data, time referenced and earth located, with absolute radiometric and geometric calibration coefficients appended, but not applied, to the data. Aggregates (sums or weighted averages) of detector samples are considered to be full resolution data if the aggregation is normally performed to meet resolution and other requirements. Sensor data shall be unprocessed with the following exceptions: time delay and integration (TDI), detector array non-uniformity correction (i.e., offset and responsivity equalization), and data compression are allowed. Lossy data compression is allowed only if the total measurement error is dominated by error sources other than the data compression algorithm. All calibration data will be retained and communicated to the ground without lossy compression.

Refresh

The specified refresh thresholds represent the maximum value of the local average revisit time over the set of all locations on the Earth's surface; where the local average revisit time represents the average time interval between consecutive measurements of a parameter at a given location on the Earth's surface over a time period required for the ground trace to repeat.

Remedial Maintenance

Maintenance undertaken after a failure in order to correct a failure that has occurred in a system that renders the system unable to fully perform its required mission, sometimes referred to as corrective maintenance or unscheduled maintenance.

Revisit Time

The time interval between consecutive measurements of a parameter at the same location.

Satellite Nadir Resolution

Resolution along satellite's nadir path.

Scene Albedo

The ratio of the amount of visible spectrum electromagnetic radiation returned to space by scattering and reflection from a given aerial region of the Earth's surface, atmosphere, and clouds, to the amount of visible spectrum electromagnetic energy incident upon that region.

Second Year Ice

Sea ice, which has survived one summer's melt, with a thickness of 3 m or more. Most topographic features are smoother than on first-year ice.

Sensor Data Record (SDR)

Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to geolocated, calibrated brightness temperatures with associated ephemeris data. Temperature Data Records (TDRs) are geolocated, antenna temperatures with all relevant calibration data counts and ephemeris data to revert from T-sub-a into counts. The existence of the SDRs provides reversible data tracking back from the EDRs to the Raw data.

Significant Wave Height *(For Sea Surface Height EDR)*

The height of a theoretical wave whose height and period are equal to the average height and period of the largest one-third of the actual waves that pass a fixed point in some time period.

Space Segment

The spacecraft including its associated sensors, subsystems, equipment, and processors.

Specific Humidity

The mass of water vapor contained in a unit mass of air (dry air plus water vapor) expressed in grams per kilogram.

Surface Albedo

The amount of visible solar radiation (0.4 – 4.0 µm) reflected by the earth's surface into a hemisphere divided by the amount incident. The major applications are twofold: 1) characterization of backgrounds by electro-optical systems; and 2) use in the visible cloud/no cloud decision for processed cloud data.

Swath-width

The area imaged perpendicular to the satellite track by a Synthetic Aperture Radar (SAR). Regional scale is defined by a 500 km swath, Littoral scale is defined by a 100 km swath and Local Scale is defined by a 50 km swath.

TACTERMs

Tactical field component terminals such as the AN/SMQ-11 and NITES or the FMQ-17 used by the USN and the METMF(R) used by the USMC; and the Mark IV, the Mark IVB, and the AN/TMQ-43 (Small Tactical Terminal) used by the AF

TEMPEST

Short name referring to the investigation, study, and control of compromising emanations from telecommunications and automated information systems equipment.

Temperature Data Record (TDR)

Temperature Data Records are geolocated, antenna temperatures with all relevant calibration data counts and ephemeris data to revert from T-sub-a into counts.

Threshold

The minimum requirement below which utility of the system becomes questionable.

Tides

The periodic component of the sea surface topography induced by the gravitational interaction between the Earth, the Sun and the Moon.

Thick First- year Ice

First-year ice with a thickness of greater than 120 cm.

Thin first-year/white ice

First year ice 30-70 cm thick.

Timeliness

Same as Latency.

Tropical Cyclone

The atmospheric phenomena characterized by a barotropic disturbance forming over tropical waters. The progression generally includes Tropical Depression, Tropical Storm and Hurricane/Typhoon/Cyclone.

Tropopause Height

The height of the tropopause, which is the upper boundary of the troposphere, where there is an abrupt change with respect to how the temperature changes with height, going from decreasing with height below the tropopause to increasing with height above the tropopause.

Users

The people, such as weather forecasters, who employ the obtained environmental data.

Vertical Cell Size

For a parameter which is an estimate of the uniform spatial average of an environmental parameter within a square layer of the atmosphere, the vertical thickness of this layer.

Vertical Coverage

The specified vertical region of interest where data are to be collected or information is to be provided.

Vertical Reporting Interval

The spacing between nearest neighbor points along a local vertical at which an environmental parameter is estimated and reported.

Visibility

The ability to detect objects through a layer of the atmosphere.

White Ice

See Thin first year ice.

Requirements Correlation Matrix (RCM)
RCM PART I–
(Tabular Summary of System Characteristics and Capabilities)
(General Requirements)

This RCM describes, in three separate tables, General Requirements, Key Environmental Data Records, and Other Environmental Data Records. A blank entry in the IORD II column indicates that the IORD I value has not changed.

IORD I SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD II	
	Thresholds	Objectives		Thresholds	Objectives
Para 4.1.x			Para 4.1.x		
5.1. Data Availability (DoD/DOC) a. To Centrals b. To EDR level c. To Field Terminals	 97.50% 95% Field of View	 TBD TBD TBD		 99% Continual (100%)	 100% 99.8% N/A
5.2. Autonomous Operations (DoD) a. Duration b. Mapping Uncertainty	 21 days 45 km	 60 days 1 km			
5.3. Stored High Resolution Data (DoD/DOC) Deleted in IORD II.	1/2 Orbit			Combined 5.3 & 5.4	
5.4. Surface Data Collection/Location (DOC/DoD).	ARGOS	TBD	5.3. Surface Data Collection/Location (DOC/DoD) .		
5.5. Orbital Characteristics (DoD/DOC)	Same lat imaged at same LST: 1330, 1730, 2130 daylight ascending Evenly spaced orbits . Precise orbit. Exact ground track repeat.	User selectable times.	5.4. Orbital Characteristics (DoD/DOC)	Precise orbit.(±10 min LTAN)	
5.5 Orbital Characteristics for Sea Surface Height Measurement (DoD)				Ground Track Repeat of ± 1 km	
5.6. System Survivability (DoD)	See Attachment 4.	See Attachment 4.		See Attachment 2.	See Attachment 2.
5.7. Search and Rescue (DOC)	Equipment IAW International agreements.				
5.8. Compatibility(DOC)	Minimize impact to existing user terminals.				
5.9. Space Debris Minimization (DoD/DOC)	IAW Satellite Disposal Procedures in UPD 10-39, 3 Nov 97 and AFSPC 10-120104, Satellite Control			IAW NASA Safety Std. 1740.14; UPD 10-39; NSP Sep. 19, 1996	
5.10. *Data Access (*DoD)	**Selectively deny all U.S. environmental sensor data**				
5.11 Interoperability*				**100% of all critical IERs**	**All IERs**
5.12. Geolocation of Data (DoD)	Ability to precisely locate data & provide location data with RDRs				
5.13. Space Environmental Constellation Characteristics (DoD/DOC)	SESS data from all orbital planes..			See Section 4.1.6.8	
6.x.x (see sections 2 and 3 of Part 1)					

IORD I SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD II	
	Thresholds	Objectives		Thresholds	Objectives
Para 4.1.x			Para 4.1.x		
7. Interfaces					
7.1.1 Space Segment to Launch Segment	Minimal preparation; U.S. launch sites.				
7.1.2 Space Segment to C3 Segment				Support all CCC interfaces that enable T & C. Capability to preclude interference or authorized contact.	
7.1.3 Space Segment to Field Terminals	Compatible with minimal impact on Centrals and DoD field terminals. Modify DoD field terminals as needed to receive and process NPOESS data, without exceeding current field terminal size, weight, power, and environment constraints.			Provide real-time data to Field Terminals.	
7.1.4 Surface Data Collection to Space Segment	Allow transmissions from ARGOS or its follow-on.			Enable receipt of data from ARGOS (or its follow-on)	
7.1.5 Search and Rescue to Space Segment				Enable the receipt of SAR transmissions by the satellite and the rebroadcast of SAR data by the SARR	
7.2 Launch Support Segment	Interface with launch site, space segment, and C3 segment for launches.				
7.3 C3 Segment					
7.3.1 C3 to Scheduling Resources				With the appropriate scheduling agencies	
7.3.2 For Orbit Determination	Interface with NORAD.			GPS location, then NORAD	
7.3.3 To Centrals IDP Segment				Minimize impact on existing Centrals	
7.4 IDP Segment Interfaces					
7.4.1 to Centrals				Provide NPOESS data to Centrals. Receive data from Centrals.	
7.4.2 to Field Terminals				Functionality to receive and process real-time NPOESS data	
8. Flexibility and Expansion	Allow for variations in operation without system redesign.				
5. Deleted	Interoperability of hardware and software				
9 IDP Segment Computer Capacity	100% of worst case scenario, to include processing and memory.			Ingest, process, and store twice the worst case data loading scenario	

IORD I SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD II	
	Thresholds	**Objectives**		**Thresholds**	**Objectives**
			Para 4.2.x		
			0. Information Exchange Requirements	See 5.3.5 and Table B	See 5.3.5 and Table B

IORD I SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD II	
	Thresholds	**Objectives**		**Thresholds**	**Objectives**
Para 4.2.x			**Moved to Para 4.3.x**		
1 System Operational Availability (A_o)			4.3.1 System Operational Availability (A_o)	93% wartime and peacetime	95% wartime and peacetime
a. Ao	95%				
b. Deleted.	TBD	TBD			
c. Deleted.	TBD	TBD			
2 Space Segment			**4.3.2 Space Segment**		
2.1 Minimum Useful Lifetime	10 years (system)	TBD	4.3.2.1		
2.2 Maintainability		TBD	4.3.2.2	Ensure timely replacement or test of spacecraft sub-systems or sensors prior to launch.	
2.3 C^3 Ground Equipment and IDP Segment Equipment.	No on-orbit repair.		4.3.2.3	Diagnostics capability for fault isolation and remediation.	
3.1 Fault Detection	Automatically or manually detect 98% of faults.	Automatically or manually detect 99% of faults.	4.3.3.1	Detect 98% of faults.	Detect 99% of faults.
3.2 Fault Isolation	Automatically or manually isolate 98% of faults.	Automatically or manually isolate 99% of faults.	4.3.3.2	Isolate 98% of faults: capable of operator initiation.	Isolate 99% of faults
3.3 Notification of System Faults			4.3.3.3	Detection of system fault immediately, implementation of work-around within 30 minutes, complete fault isolation and correction ASAP while maintaining A_0.	Failed component returned to operations within 4 hours.

IORD I SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD IISYSTEM CAPABILITIES AND CHARACTERISTICS	IORD II	
	Thresholds	**Objectives**		**Thresholds**	**Objectives**
Para 4.3.x			**Moveed to Para 4.4**		
1.1 NBC Survivability	See IORD Attachment 4.		4.4.1	See IORD Attachment 2	
1.2 Segment Environmental Survivability			4.4.2 Natural Environmental Factors		
1.2.1 Space Segment	Operate reliably in space environment for which it is intended. See IORD Attachment 4..		4.4.2.1	Operate reliably in space environment for which it is intended. See IORD Attachment 2..	
1.2.2 C^3 Segment	See IORD Attachment 4.		4.4.2.2	See IORD Attachment 2.	
1.2.3 IDP Segment	Environmentally controlled facilities, with backup power sources able to withstand local weather conditions.		4.4.2.3		
2 Security			4.4.4	IAW appropriate tri-agency documents as determined IAW the tri-agency MOA.	
2.1 Information Security	IAW applicable DoD, DOC and IPO directives.		4.4.4.1		
2.2 Personnel Security	IAW DoD, DOC and NASA directives.		4.4.4.2		
2.3 Physical Security	IAW DoD, DOC and NASA directives.		4.4.4.3		

IORD I SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD IISYSTEM CAPABILITIES AND CHARACTERISTICS	IORD II	
	Thresholds	Objectives		Thresholds	Objectives
Para 4.3.x			**Moveed to Para 4.4**		
2.4 Industrial Security	IAW DoD, DOC and NASA directives.		4.4.4.4		
2.5.1 COMSEC	Uplink and downlink signals capable of being encrypted; Uplinked commands shall pass through an authentication procedure on the spacecraft; results of authentication attempts will be telemetry linked to the C3 segment.		4.4.4.5.1		
2.5.2 OPSEC	Developed IAW DoD, DOC and NASA directives.		4.4.4.5.2		
2.5.3 TEMPEST	Proportional to threat of exploitation and the potential damage to National Security.		4.4.4.5.3		
2.5.4 COMPUSEC	IAW DoD, DOC and NASA directives.		4.4.4.5.4		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD II	
	Thresholds	Objectives		Thresholds	Objectives
Para 4.4.x			**Para 4.4.x**		
1Range Safety Compliance	IAW applicable Eastern/Western Test Range requirements.		4.4.3.1		
2 End-of-Life Safety	IAW space debris minimization policies.	Designed so that non-mission capable s/c or s/c nearing end of life can be removed from operational orbits.	4.4.3.2		
			4.4.5 Electromagnetic Effects and Spectrum Supportability		
			4.4.5.1 Space Segment to C^3 Segment Interface	USB Compatible Command uplink encrypted Automatic Tracking	
			4.4.5.2 <u>Space Segment to Field Terminal Component Interface</u>	Broadcast IAW Table C	
			4.4.5.3 <u>C^3 Segment to Central IDP Segment Interface</u>	Communications as required	
			4.4.5.4 <u>Electromagnetic Compatibility</u>	Compatible with self and GFE IAW DoD and DOC policy	
			4.4.5.5 <u>Radio Frequency Spectrum Supportability</u>	Comply with national and international regulations	

Requirements Correlation Matrix
Part 1
(Key Environmental Data Records)

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Key (Para 4.1.6.1.x)				
1 Atmospheric Vertical Moisture Profile (*DOC/*DoD)				
a. Horizontal Cell Size	15 km at nadir	2 km		1
b. Vertical Reporting Interval				
1. Surface to 850 mb	20 mb	5 mb		
2. 850 to 100 mb	50 mb	15 mb		10 mb
c. Mapping Accuracy	5 km	1 km		0.5 km
d. Measurement Uncertainty (g kg^{-1})		10 %		
Clear:				
1. Surface to 600 mb*	**20 % (DoD: 25 %)**		**Greater of 20 % or 0.2 g kg^{-1} (DoD: 25 %)**	10 %
2. 600 to 300 mb	35 %		Greater of 35 % or 0.1 g kg^{-1}	10 %
3. 300 to 100 mb	35 %		Greater of 35% or 0.1 g kg^{-1}	10 %
Cloudy:				
4. Surface to 600 mb*	**20 % (DoD: 25 %)**		**Greater of 20 % or 0.2 g kg^{-1} (DoD 25 %)**	10 %
5. 600 to 400 mb	40 %		Greater of 40 % or 0.1 g kg^{-1}	10 %
6. 400 to 100 mb	40 %		Greater of 40 % or 0.1 g kg^{-1}	10 %
e. Latency			156 minutes	15 minutes
f. Refresh	6 hrs	3 hrs		
g. Long Term Stability			2 %	1 %

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Key (Para 4.1.6.1.x)				
2 Atmospheric Vertical Temperature Profile (*DOC/*DoD)				
a. Horizontal Cell Size				
1. Clear, nadir	18.5 km	5 km		1 km
2. Clear, worst case	100 km			
3. Cloudy, nadir	40 km	5 km		1 km
4. Cloudy, worst case	50 km			
b. Vertical Reporting Interval				
1. Surface to 850 mb	20 mb	15 mb		10 mb
2. 850 to 300 mb	50 mb	15 mb		10 mb
3. 300 to 100 mb	25 mb	15 mb		10 mb
4. 100 to 10 mb	20 mb	10 mb		
5. 10 to 1 mb	2 mb	1 mb		
6. 1 to 0.1 mb	0.2 mb	0.1 mb		
7. 0.1 to 0.01 mb	0.02 mb	0.01 mb		
c. Mapping Accuracy	5 km	1 km		0.5 km
d. Measurement Uncertainty		0.5 K		
Clear:				
1. Surface to 300 mb*	**1.6 K per 1 km layer**			
2. 300 to 30 mb	1.5 K per 3 km layer			
3. 30 to 1 mb	1.5 K per 5 km layer			
4. 1 to 0.01 mb	3.5 K per 5 km layer			
Cloudy:				

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Key (Para 4.1.6.1.x)				
5. Surface to 700 mb*	**2.5 K per 1 km layer**			
6. 700 to 300 mb	1.5 K per 1 km layer			
7. 300 to 30 mb	1.5 K per 3 km layer			
8. 30 to 1 mb	1.5 K per 5 km layer			
9. 1 to 0.01 mb	3.5 K per 5 km layer			
e. Latency			156 minutes	15 minutes
f. Refresh	6 hrs	3 hrs		
g. Long Term Stability			Trop mean 0.05 K Strat mean 0.1 K	0.03 K 0.05 K

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Key (Para 4.1.6.1.x)				
3. Global Sea Surface Winds* (*DoD/*DOC)				
a. Horizontal Cell Size	20 km	1 km		
b. Mapping Uncertainty	5 km	1 km		
c. Measurement Range	3 to 25 m s^{-1}, 0-360 deg	1 to 50 m s^{-1}, 0-360 deg		
d. Measurement Precision.	1 ms^{-1}; 10 deg dir	1 ms^{-1}; 10 deg dir	(Characteristic deleted in IORD II)	Characteristic deleted in IORD II)
e. Measurement Accuracy				
1. Speed*	**2 m s^{-1} or 10 % speed, whichever is greater;**	1 m s^{-1} or 10 % speed, whichever is greater;		
2. Direction	20 deg	10 deg	20 deg for wind speed > 5 m s^{-1} (25 deg for wind speeds 3-5 m s^{-1})	
f. Refresh	6 hours	1 hour		
g. Long Term Stability			0.5 m s^{-1} decade^{-1}	
h. Latency			90 minutes	15 minutes
i. Geographic Coverage			Global ice-free ocean	Global ice-free ocean

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Key (Para 4.1.6.1.x)				
4 Imagery (*DoD/*DOC)				
a. Horizontal Cell Size				
DoD-Vis, IR, and stratus/fog discrimination in regional resolution				
Nadir	**1.0 km at nadir**		0.4 km	0.1 km
Worst Case	2.4 km worst case	0.65 km	0.8 km	0.1 km
All weather	**0.4 km at nadir**		40 km	20 km
Night-time visual	2.6 km worst case	0.65 km		
b. Mapping Accuracy	3 km at nadir		1 km at nadir 3 km worst case 5 km all weather	 0.5 km 3 km
c. Refresh (*DoD)	**(For visible and IR) At any location: a) the average revisit time will be 4 hours or less and the maximum revisit time will be 6 hours or less; b) at least 75 % of the revisit times will be 4 hours or less**	1 hour		
d. Latency			90 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Key (Para 4.1.6.1.x)				
5. Sea Surface Temperature (*DOC/*DoD)				
a. Horizontal Cell Size				
1. **Nadir, clear***	**3 km**	1 km	**1.0 km**	0.25 km
2. Clear, worst case	4 km		1.3 km	
3. All weather	1 km	0.25 km	40 km	20 km
4. Regional, worst case. Deleted in IORD II	1.3 km			
b. Mapping Accuracy				
1. Nadir, clear	1 km	0.5 km		0.1 km
2. Clear, worst case	3 km		1.3 km	
3. All weather	1 km	0.1 km	5 km	3 km
4. Regional, worst case. Deleted in IORD II.	3 km			
c. Measurement Range	-2 deg C to 40 deg C	-2 deg C to 40 deg C		
d. Measurement Precision	0.2 deg C	0.1 deg C	Clear 0.2 deg C All weather 0.3 deg C	Clear 0.1 deg C All weather 0.1 deg C
e. **Measurement Uncertainty***	**0.5 deg C**	0.1 deg C		
Clear*			**0.5 deg C**	0.1 deg C
All weather			1.0 deg C	0.5 deg C
f. Refresh	6 hours	3 hours		
g. Long Term Stability			0.1 deg C	0.05 deg C
h. Latency			90 minutes	15 minutes
i. Geographic Coverage			Global ocean	Global ocean

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Key (Para 4.1.6.1.x)				
6. Soil Moisture (*DoD/DOC)				
a. Sensing Depth*	**surface (skin layer: to – 0.1 cm)**	surface to –80 cm		
b. Horizontal Cell Size				
1. Clear, nadir	1 km			0.5 km
2. Clear, worst case	4 km	2 km		
3. Cloudy, nadir	40 km	2 km		
4. Cloudy, worst case	50 km			2 km
c. Vertical Sampling Interval	Not required	5 cm		
d. Mapping Accuracy, clear nadir	3 km	1 km	1 km	0.5 km
e. Mapping Accuracy, cloudy			5 km	1 km
f. Measurement Uncertainty	Bare soil, in regions with known soil types: 10 % (low HCS) 20 % (high HCS - clear skies)	sfc: $\pm$1 cm m^{-1} 80 cm column: 5 % or 130 %		80 cm column: 5 %
i. Refresh	8 hrs	3 hrs		
g. Measurement Range			0-100 %	0-100 %
h. Latency			90 minutes	30 minutes

Requirements Correlation Matrix
Part 1
(Other Environmental Data Records)

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.2.x - Atmospheric Parameters				
1. Aerosol Optical Thickness (DOC)/(DoD)				
a. Vertical Coverage	Surface to 30 km	Surface to 50 km		
b. Horizontal Cell Size	10 km	1 km		
c. Vertical Cell Size	Total Column			
1. From 0 to 2 km		0.25 km		
2. From 2 to 5 km		0.5 km		
3. > 5 km		1 km		
d. Mapping Accuracy	4 km	1 km		
e. Measurement Range	0 to 2	0 to 10		
1. Operational			0 - 2	0 - 10
2. Climate			0 - 5	0 - 10
f. Measurement Precision	0.03	0.01		
1. Operational			0.03	0.01
2. Climate			0.01 over ocean 0.03 over land	0.005 over ocean 0.02 over land
g. Measurement Accuracy	0.03 over ocean	0.01		
1. Operational			0.03 over ocean	0.01
2. Climate			Greater of 0.02 or 7 % over ocean Greater of 0.04 or 10 % over land	Greater of 0.01 or 5 % over ocean Greater of 0.03 or 7 % over land
h. Latency			90 minutes	15 minutes
i. Refresh	6 hrs	4 hrs; 2 hrs during daylight		
1. Operational			6 hours	4 hours
2. Climate			N/A	N/A
j. Long Term Stability	0.01	0.003		0.005

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.2.x - Atmospheric Parameters				
2. Aerosol Particle Size (DOC/DoD)				
a. Vertical Coverage	Surface to 30 km	Surface to 50 km		
b. Horizontal Cell Size	10 km	1 km		
c. Vertical Cell Size	Total Column			
1. From 0 to 2 km		0.25 km		
2. From 2 to 5 km		0.5 km		
3. > 5 km		1 km		
d. Mapping Accuracy	4 km	1 km		
e. Measurement Range	-1 to +3	-2 to +4		
1. Operational			-1 to +3	-2 to +4
2. Climate			0 to 5 µmfor r_e 0 to 3 for ν_e	0 to 10 µm for r_e 0 to 5 for ν_e
f. Measurement Precision	0.3	0.1		
1. Operational			0.3	0.1
2. Climate			Greater of 0.05 µm or 10 % for r_e Greater of 0.1 or 40 % for ν_e	Greater of 0.05 µm or 5 % for r_e Greater of 0.1 or 20 % for ν_e
g. Measurement Accuracy				
1. Operational	0.3 over ocean	0.1		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.2.x - Atmospheric Parameters				
2. Climate			Greater of 0.1 µm or 10 % for r_e Greater of 0.3 or 50 % for ν_e	Greater of 0.05 µm or 5 % for r_e Greater of 0.2 or 30 % for ν_e
h. Refresh	6 hours	4 hours; 2 hrs during daylight	6 hours	4 hours
			N/A	24 hours
i. Long Term Stability	0.1	0.03	Greater of 0.05 µm or 10 % for r_e Greater of 0.2 or 40% for ν_e	Greater of 0.05 µm or 5 % for r_e Greater of 0.1 or 20 % for ν_e

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.2.x - Atmospheric Parameters				
3. Aerosol Refractive Index, Single-scattering albedo, and Shape (DOC)				
a. Vertical Coverage			Surface to 30 km	Surface to 50 km
b. Horizontal Cell Size			10 km	1 km
c. Vertical Cell Size			Total Column	
1. From 0 to 2 km				0.25 km
2. From 2 to 5 km				0.5 km
3. Greater than 5 km				1 km
d. Mapping Accuracy			4 km	1 km
e. Measurement Range			1.3 to 1.7 for m, 0 to 1 for ϖ	1.3 to 1.8 for m, 0 to 1 for ϖ
f. Measurement Precision			0.01 for m, 0.02 for ϖ	0.005 for m, 0.01 for ϖ
g. Measurement Accuracy			0.02 for m, 0.03 for ϖ	0.01 for m, 0.01 for ϖ
h. Refresh			N/A	N/A
i. Long Term Stability			0.01 for m, 0.02 for ϖ	0.005 for m, 0.01 for ϖ

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.2.x - Atmospheric Parameters				
4. Ozone Total Column/Profile (DOC)				
a. Horizontal Cell Size				
1. Total Column	50 km at nadir	50 km worst case		
2. Profile	250 km	250 km		
b. Vertical Cell Size				
1. 0 - TH	N/A	3 km		
2. TH - 25 km	5 km	1 km		
3. 25 - 60 km	5 km	3 km		
c. Mapping Accuracy				
1. Total Column, at nadir	5 km	5 km		
2. Profile	25 km	25 km		
d. Measurement Range				
1. Total Column	0.05 to 0.65 atm-cm	0.05 to 0.65 atm-cm		
2. Profile				
a. 0 - TH	N/A	0.01 to 3 ppmv		
b. TH - 60 km	0.1 to 15 ppmv	0.1 to 15 ppmv		
e. Measurement Precision				
1. Total Column	0.001 atm-cm	0.001 atm-cm	0.003 atm-cm + 0.5 % of measured ozone	0.001 atm-cm
2. Profile				
a. 0 - TH	N/A	10 %		
b. TH - 15 km	10 %	3 %	Greater of 10 % or 0.1 ppmv	3 %
c. 15 - 50 km	3 %	1 %	Greater of 3 % and 0.05 ppmv	1 %

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.2.x - Atmospheric Parameters				
d. 50 - 60 km			Greater of 10 % or 0.1 ppmv	3 %
f. Measurement Accuracy	10%	3%		
1. Total Column	0.015 atm-cm	0.005 atm-cm		
2. Profile				
a. 0 - TH	N/A	10 %		
b. TH - 15 km	20 %	10 %	Greater of 20 % or 0.1 ppmv	10 %
c. 15 - 60 km	10 %	5 %	Greater of 10 % or 0.1 ppmv	5%
g. Latency			120 minutes	15 minutes
h. Refresh				
1. Total Column	24 hrs	24 hrs		
2. Profile	7 days	24 hrs		
i. Long Term Stability				
1. Total Column	1 %	0.50 %	1 % over 7 years	0.5 % over 7 years
2. Profile	2 %	1 %	2 % over 7 years	1 % over 7 years

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.2.x - Atmospheric Parameters				
5. Precipitable Water/Integrated Water Vapor (DOC/DoD))				
a. Vertical Coverage	Surface to TOA			
b. Horizontal Cell Size	25 km	1 km		
c. Mapping Accuracy	3 km	0.1 km	5 km	
d. Measurement Range	0 to 75 mm	0 to 100 mm		
e. Measurement Precision	1 mm	1 mm		
f. Measurement Accuracy	Greater of 2 mm or 10%	1 mm		Greater of 1 mm or 4 %
g. Latency			90 minutes	15 minutes
h. Refresh	6 hrs	3 hours	8 hours	
i. Long Term Stability			Greater of 1 mm or 4 %	Greater of 0.2 mm or 1 %

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.2.x - Atmospheric Parameters				
6. Precipitation Type/Rate (DoD/DOC)				
a. Horizontal Cell Size	15 km	0.1 km		
b. Mapping Accuracy	3 km	0.1 km	5 km	
c. Measurement Range	0 to 250 mm hr^{-1}		0 to 50 mm hr^{-1}	
d. Measurement Precision	1 mm hr^{-1}	1 mm hr^{-1}		
e. Measurement Accuracy	2 mm hr^{-1}	2 mm hr^{-1}		
f. Latency			90 minutes	15 minutes
g. Refresh	8 hrs	3 hrs		1 hour
h. Long Term Stability			1 mm hr^{-1} or 10 %	0.1 mm hr^{-1} or 1 %

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.2.x - Atmospheric Parameters				
7. Pressure (Surface/Profile) (DoD)				
a. Vertical Coverage	Surface to 30 km	Surface to 30 km		
b. Horizontal Cell Size	25 km	5 km		
c. Vertical Cell Size				
1. 0 - 2 km	1 km	0.25 km		
2. 2 - 5 km	1 km	0.5 km		
3. > 5 km	1 km	1 km		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.2.x - Atmospheric Parameters				
d. Mapping Accuracy	7 km	1 km		
e. Measurement Range	10 to 1050 mb	10 to 1050 mb		
f. Measurement Precision	4 mb	2 mb		
g. Measurement Accuracy				
1. 0 to 10 km	± 5 %	± 3%	Greater of 1 % or 10 mb	0.5 %
2. 10 to 30 km	± 10%	± 5%	Greater of 1 % or10 mb	0.5 %
h. Latency			156 minutes	15 minutes
i. Refresh	12 hrs	1 hr		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.2.x - Atmospheric Parameters				
8. Suspended Matter (DoD/DOC)				
a. Horizontal Cell Size	3 km	1 km		
b. Vertical Cell Size	Total Column	0.2 km		
c. Mapping Uncertainty	3 km	0.1 km		
d. Measurement Range				
(1) Detect Suspended Matter	Dust, sand, and ash	dust, sand, ash & sea salt	Dust, sand, ash, SO_2	Dust, sand, ash, SO_2, sea salt
(2) Radioactive/Smoke Plumes	TBD	0 to 100 $\mu g\ m^3$ (smoke)	N/A	
e. Latency			90 minutes	15 minutes
f. Refresh	12 hrs	3 hrs		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.2.x - Atmospheric Parameters				
9. Total Water Content (DoD)				
a. Horizontal Cell Size	20 km	10 km		
b. Vertical Cell Size	3 km	1 km		
c. Mapping Accuracy	7 km	7 km		
d. Measurement Uncertainty				
1. Point Measurement	2 kg m^{-2}, 1 kg m^{-2} global avg		2 kg m^{-2}	
2. Global Average	0.2 kg m^{-2}, over ocean only		1 kg m^{-2}	
e. Latency			90 minutes	15 minutes
f. Refresh	8 hrs	3 hrs		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.3.x - Cloud Parameters				
1. Cloud Base Height (DOC/DoD)				
a. Horizontal Cell Size	25 km	10 km		1 km
b. Vertical Reporting Interval	TBD	0.25 km	Base of up to four layers	Base of all distinct cloud layers
c. Mapping Accuracy	4 km	1 km	2 km	
d. Measurement Uncertainty	2 km	0.25 km		
e. Latency			90 minutes	15 minutes
f. Refresh	6 hrs	4 hrs		
g. Long Term Stability			2.0 km	0.1 km

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.3.x - Cloud Parameters				
2. Cloud Cover/Layers (DoD/DOC)				

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.3.x - Cloud Parameters				
a. Horizontal Cell Size	25 km	2 km		1 km
b. Vertical Reporting Interval	4 layers	0.1 km		
c. Mapping Uncertainty	4 km	1 km		
d. Measurement Range	0 to 100 %	0 to 100 %	0 to 1.0	0 to 1.0
e. Measurement Precision	15 % (layers)	2.50 %	15 %	
f. Measurement Accuracy	10 % (cover)	5 %	10 %	
g. Latency			90 minutes	15 minutes
h. Refresh	6 hrs	4 hrs		
i. Long Term Stability			0.1	0.002

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.3.x - Cloud Parameters				
3 Cloud Particle Size Distribution (DOC/DoD)				
a. Horizontal Cell Size			15 km	5 km
b. Vertical Reporting Interval			1 km	0.3 km
c. Mapping Uncertainty			4 km	1 km
d. Measurement Range			0 to 50 μm for r_e, 0 to 2 for ν_e	0 to 80 μm for r_e, 0 to 3 for ν_e
e. Measurement Precision			Greater of 0.5 μm or 5 % for r_e Greater of 0.04 or 40 % for ν_e	Greater of 0.3 μm or 3 % for r_e Greater of 0.03 or 30 % for ν_e
f. Measurement Accuracy			Greater of 1 μm or 10 % for r_e Greater of 0.05 or 50 % for ν_e	Greater of 0.5 μm or 5 % for r_e Greater of 0.04 or 40 % for ν_e
g. Refresh			N/A	N/A
h. Long Term Stability			Greater of 0.5 μm or 5 % for r_e Greater of 0.04 or 40 % for ν_e	Greater of 0.3 μm or 3 % for r_e Greater of 0.03 or 30 % for ν_e

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.3.x - Cloud Parameters				
4. Cloud-Effective Particle Size (DOC/DoD)				
a. Horizontal Cell Size	50 km	10 km		1 km
b. Vertical Reporting Interval	1 km	0.3 km		
c. Mapping Uncertainty	4 km	1 km	2 km	1 km
d. Measurement Range	0-50 μm			
e. Measurement Precision	greater of 5% or 2 μm	2%		
f. Measurement Accuracy	greater of 10% or 4 μm	greater of 5% or 2 μm		
g. Latency			90 minutes	15 minutes
h. Refresh	8 hrs	3 hrs	6 hrs	4 hrs
i. Long Term Stability	2%	1%		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.3.x - Cloud Parameters				
5. Cloud Ice Water Path (DOC)				
a. Vertical Coverage	Surface to 15 km	Surface to 20 km	**Surface to 20 km**	
b. Horizontal Cell Size	50 km	10 km		
c. Vertical Reporting Interval	Total Column	0.3 km		
d. Mapping Uncertainty	4 km	1 km	5 km	
e. Measurement Range	0 to 1 mm	0 to 1 mm	0.01 to 1 mm	0 to 2 mm
f. Measurement Precision	5 %	2 %	Greater of 0.05 mm or 10 %	Greater of 0.02 mm or 4 %
g. Measurement Accuracy	10 %	5 %	Greater of 0.1 mm or 25 %	Greater of 0.05 mm or 10 %
h. Latency			156 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.3.x - Cloud Parameters				
i. Refresh	6 hrs	3 hrs	8 hrs	
j. Long Term Stability	2 %	1 %		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.3.x - Cloud Parameters				
6. Cloud Liquid Water (DOC/DoD)				
a. Horizontal Cell Size	20 km	5 km		1 km
b. Vertical Reporting Interval	Total Column	0.3 km		
c. Mapping Uncertainty	7 km	1 km	5 km	
d. Measurement Uncertainty	0.5 mm over ocean 0.25 mm over land	0.01 mm	± 0.25 mm over ocean ± 0.50 mm over land	
e. Latency			90 minutes	15 minutes
f. Refresh	8 hrs	4 hours		
g. Range			0.005 to 1 mm	0 to 2 mm
h. Long Term Stability			Greater of 0.05 mm or 10 %	Greater of 0.01 mm or 1 %

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.3.x - Cloud Parameters				
7. Cloud Optical Thickness(DOC)				
a. Horizontal Cell Size	50 km	10 km		
b.Vertical Sampling Interva			Total Column	4 layers
c. Mapping Uncertainty	4 km	10 km		1 km
d. Measurement Precision	5 %	2 %	Greater of 5 % or 0.025 optical depth	
e. Measurement Accuracy	10 %	5 %	Greater of 10 % or 0.05 optical depth	
f. Latency			90 minutes	15 minutes
g. Refresh	8 hrs	3 hrs		
h. Long Term Stability	2 %	1 %		
l				

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.3.x - Cloud Parameters				
8. Cloud Top Height (DOC/DoD)				
a. Horizontal Cell Size	25 km	10 km		1 km
b. Vertical Reporting Interval	Four layers	0.25 km	Tops of up to four layers	Tops of all distinct cloud layers
c. Mapping Uncertainty	4 km	1 km		
d. Measurement Precision	0.3 km	0.15 km		
e. Measurement Accuracy				
1. Optically thick:	± 0.5 km	0.3 km	1.0	
2. Optically thin:	2 km	0.3 km		
f. Latency			90 minutes	15 minutes
g. Refresh	8 hrs	6 hrs	6 hrs	4 hrs
h. Long Term Stability	0.2 km	0.1 km		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.3.x - Cloud Parameters				
9. Cloud Top Pressure (DOC)				
a. Horizontal Cell Size	15 km	10 km	25 km	1 km
b. Mapping Uncertainty	4 km	1 km	2 km	1 km
c. Measurement Precision				
1. sfc to 3 km	50 mb	10 mb		
2. 3 to 7 km	38 mb	7 mb		
3. > 7 km	25 mb	5 mb		
d. Measurement Accuracy				
1. sfc to 3 km	100 mb	30 mb		
2. 3 to 7 km	75 mb	22 mb		
3. > 7 km	50 mb	15 mb		
e. Latency			90 minutes	15 minutes
f. Refresh	8 hrs	3 hrs	6 hours	4 hours
g. Long Term Stability				
1. sfc to 3 km	10 mb	3 mb		
2. 3 to 7 km	7 mb	2 mb		
3. > 7 km	5 mb	1 mb		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.3.x - Cloud Parameters				
10. Cloud Top Temperature (DOC/DoD)				
a. Horizontal Cell Size	25 km	10 km		1 km
b. Mapping Uncertainty	4 km	1 km		
c. Measurement Precision	1.5 K	0.5 K		
d. Measurement Accuracy	3 K	1.5 K		
1. Optically thick			3 K	1.5 K
2. Optically thin			6 K	2 K
e. Latency			90 minutes	15 minutes
f. Refresh	6 hrs	6 hrs		4 hrs
g. Long Term Stability	1 K	0.1 K		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.4.x - Earth Radiation Budget Parameters				
1. Albedo (Surface) (DOC/DoD)				
a. Horizontal Cell Size	4 km	0.5 km		
b. Mapping Uncertainty	4 km	1 km		
c. Measurement Range	0 to 100 %	0 to 100 %	0 to 1.0	0 to 1.0
d. Measurement Precision	2 % (albedo units)	1 %	0.02 (albedo units)	0.02
e. Measurement Accuracy	5 % (albedo units)	1.25 %	0.03 (albedo units)	0.0125
f. Latency			150 minutes	60 minutes
g. Refresh	24 hrs	4 hrs		
h. Long Term Stability	2 % (albedo units)	1 %	0.02 (albedo units)	0.01

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.4.x - Earth Radiation Budget Parameters				
2. Downward Longwave Radiation (DLR)				

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.4.x - Earth Radiation Budget Parameters				
(Surface) (DOC)				
a. Horizontal Cell Size	40 km at nadir	10 km	25 km at nadir	10 km at nadir
b. Mapping Uncertainty	10 km		5 km at nadir	1 km at nadir
c. Measurement Range	0 to 500 W m^{2}	0 to 500 W m^{2}		
d. Measurement Precision	0.1 W m^{-2}	0.1 W m^{-2}	20 W m^{-2}	6 W m^{-2}
e. Measurement Accuracy	5 W m^{2}	1 W m^{-2}	10 W m^{-2}	3 W m^{-2}
f. Latency			150 minutes	60 minutes
g. Refresh	14 hrs	6 hrs		
h. Long Term Stability			0.5 W m^{-2}	0.2 W m^{-2}

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.4.x - Earth Radiation Budget Parameters				
3. Downward Shortwave Radiation (DOC)				
a. Horizontal Cell Size	50 km	100 km	25 km at nadir	10 km at nadir
b. Mapping Uncertainty	5 km	1 km	5 km at nadir	1 km at nadir
c. Measurement Range	0 to 1400 W m^{-2}	0 to 1400 W m^{-2}		
d. Measurement Precision	5 W m^{-2}	0.1 W m^{-2}	20 W m^{-2}	6 W m^{-2}
e. Measurement Accuracy	20 W m^{-2}	1.0 W m^{-2}	10 W m^{-2}	3 W m^{-2}
f. Latency			150 minutes	60 minutes
g. Refresh	24 hrs	24 hrs		12 hours
h. Long Term Stability			0.5 W m^{-2}	0.2 W m^{-2}

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.4.x - Earth Radiation Budget Parameters				
4. Net Solar Radiation (TOA) (DOC)				
a. Horizontal Cell Size	100 km	20 km	25 km at nadir	10 km at nadir
b. Mapping Uncertainty	10 km	5 km	5 km at nadir	2 km at nadir
c. Measurement Range	0 to 900 W m^{2}	0 to 900 W m^{2}	0 to 1400 W m^{-2}	0 to 1400 W m^{-2}
d. Measurement Precision	3 W m^{-2}	1.5 W m^{-2}	15 W m^{-2}	5 W m^{-2}
e. Measurement Accuracy	5 W m^{-2}	2.5 W m^{-2}	3 W m^{-2}	1 W m^{-2}
f. Latency			150 minutes	60 minutes
g. Refresh	12 hrs	8 hrs	24 hours	12 hours
h. Long Term Stability			0.2 W m^{-2}	0.1 W m^{-2}

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.4.x - Earth Radiation Budget Parameters				
5. Solar Irradiance-Total & Spectral (DOC)				
a. Measurement Range				
1. Total	1320 to 1420 W m^{-2}	1320 to 1420 W m^{-2}	1310 to 1420 W m^{-2}	1310 to 1420 W m^{-2}
2. Spectral (0.2 - 2 µm)	0 to 10 W m^{-2}	0 to 10 W m^{-2}	0 to 10 W $m^{-2}nm^{-1}$	0 to 10 Wm^{-2} nm^{-1}
3. 1500 nm band. Deleted in IORD II.	0 to 10 W m^{-2}	0 to 10 W m^{-2}		
b. Long Term Stability				
1. Total			0.002 % per year	0.0005 % per year
2. Spectral (0.2 - 2 µm)				
a. Less than 0.6 µm			0.02 % per year	0.01 % per year

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.4.x - Earth Radiation Budget Parameters				
5. Solar Irradiance-Total & Spectral (DOC)				
b. Greater than 0.6 μm			0.01 % per year	0.01 % per year
3. 1500 nm band. Deleted in IORD II.	0.01 % per year	0.005 % per year		
c. Measurement Precision				
1. Total	0.002 % per year	0.0005 % per year		
2. Spectral (0.2 - 2 μm)	0.02 % per year	0.01 % per year		
d. Measurement Accuracy				
1. Total	1.5 W m^{-2}	0.5 W m^{-2}	1.5 W m^{-2} (0.1 %)	0.15 W m^{-2} (0.01 %)
2. Spectral (0.2 - 2 μm)	2 %	0.5 %	1 %	0.1 %
3. 1500 nm band. Deleted in IORD II.	2 %	0.5 %		
e. Refresh	20 minute viewing sun each orbit, 1 satellite	20 minute viewing sun each orbit, 3 satellites		
f. Spectral Resolution				
1. $\lambda < 0.28$ μm			1 nm	0.1 nm
2. 0.28 μm $< \lambda < 0.4$ μm			5 nm	0.1 nm
3. $\lambda > 0.4$ μm			35 nm	1.0 nm

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.4.x - Earth Radiation Budget Parameters				
6. Outgoing Longwave Radiation (TOA) (DOC)				
a. Horizontal Cell Size	100 km	20 km	25 km at nadir	10 km at nadir
b. Mapping Uncertainty	10 km	5 km	5 km at nadir	2 km at nadir
c. Measurement Range	0 to 500 W m^2	0 to 500 W m^2		
d. Measurement Precision	3 W m^{-2}	1.5 W m^{-2}	12 W m^{-2}	5 W m^{-2}
e. Measurement Accuracy	5 W m^{-2}	2.5 W m^{-2}		2 W m^{-2}
f. Latency			150 minutes	60 minutes
g. Refresh	24 hrs (once/daytime, once/nighttime)	4 hrs	12 hrs (once/daytime, once/nighttime)	
h. Long Term Stability			0.2 W m^{-2}	0.1 W m^{-2}

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.5.x - Land Parameters				
1. Land Surface Temperature (DoD/DOC)				
a. Horizontal Cell Size	4 km	1 km		
b. Mapping Uncertainty	4 km	1 km		
c. Measurement Range	-60 to 70 deg C	-60 to 70 deg C	213 to 343 K	183 to 343 K
d. Measurement Precision	0.5 deg C	0.025 deg C		
e. Measurement Accuracy	Clear: 2.5 deg C	1 deg C		
f. Latency			90 minutes	15 minutes
g. Refresh	Clear: 6 hrs	3 hrs		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.5.x - Land Parameters				
2. Vegetation Index (DOC)				
a. Horizontal Cell Size	4 km	1km		
b. Mapping Uncertainty	4 km	1 km		
c. Measurement Range	-1 to +1	-1 to +1		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.5.x - Land Parameters				
d. Measurement Precision	0.04 NDVI units	0.02 NDVI units		
e. Measurement Accuracy	0.05 NDVI units	0.03 NDVI units		
f. Latency			90 minutes	15 minutes
g. Refresh	24 hrs	24 hrs		
h. Long Term Stability	0.04 NDVI units	0.04 NDVI units		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.5.x - Land Parameters				
3. Snow Cover/Depth (DoD/DOC)				
a. Sensing Depth	0 - 40 cm	1 m		
b. Horizontal Cell Size	Clear: 1.3 km Cloudy: 12.5 km	1 km 1 km		
c. Snow Depth Ranges	12.5 cm	> 8 cm > 15 cm > 30 cm > 51 cm > 76 cm	> 0 cm (Any snow depth)	
d. Mapping Uncertainty	Clear: 2 km Cloudy: 7 km	1 km 1 km	Clear: 3 km	
e. Measurement Uncertainty	Clear: 10 % (snow / no snow) Cloudy: 20 % (snow / no snow	10 % for snow depth		
f. Latency			90 minutes	15 minutes
g. Refresh	12 hrs	3 hrs		
h. Long Term Stability			10 %	1 % continental

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.5.x - Land Parameters				
4. Surface Type (DoD)				
a. Horizontal Cell Size			20 km	0.25 km
1. Global. Deleted in IORD II.	20 km	1 km		
2. Regional. Deleted in IORD II.	20 km	0.25 km		
b. Mapping Uncertainty	5 km	1 km		
c. Measurement Range	Identification of 21 surface types	0 to 100 % vegetation, Identification of 21 surface types	17 IGBP classes	17 IGBP classes
d. Measurement Precision	10 %	0.10 %		
e. Measurement Accuracy	70 % correct for 21 types	2 %	70 % correct for 17 types	
f. Latency			90 minutes	15 minutes
f. Refresh	24 hrs	3 hrs		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
1. Currents (DoD - near shore; DOC – surface.) Deleted in IORD II				
a. Vertical Coverage Deleted in IORD II	0 to 10 m	0 to 30 m		
b. Horizontal Cell Size Deleted in IORD II				
1. Global	4 km	1 km		
2.Regional	1.3 km	0.25 km		
c. Vertical Cell Size Deleted in IORD II	Avg Vector for 5 m layer	Avg vector for 1 m layers		
d. Mapping Uncertainty Deleted in IORD II	3 km	1 km		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
e. Measurement Range Deleted in IORD II	0 to 5 $m\ s^{-1}$, 0 to 360 deg	0 to 5 $m\ s^{-1}$, 0 to 360 deg		
f. Measurement Precision Deleted in IORD II	0.25 $m\ s^{-1}$, 15 deg	0.1 $m\ s^{-1}$, 5 deg		
g. Measurement Accuracy Deleted in IORD II	0.25 $m\ s^{-1}$, 15 deg	0.1 $m\ s^{-1}$, 5 deg		
h. Refresh Deleted in IORD II	TBD	12 hrs		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
2. Fresh Water Ice (DOC/DoD) Merged with Sea Ice Characterization in IORD II.				
a. Sensing Depth *)* Merged with Sea Ice Characterization in IORD II	Ice surface	1 m		
b. Horizontal Cell Size Merged with Sea Ice Characterization in IORD II				
1. Regional, nadir	0.4 km		4 times 0.4 km	
2. Regional, worst case	0.8 km	0.65 km	4 times 0.8 km	4 times 0.65 km
c. Mapping Uncertainty Merged with Sea Ice Characterization in IORD II	3 km	1 km		
d. Measurement Range Merged with Sea Ice Characterization in IORD II	1/10 to 10/10 concentration	0/10 to 10/10 concentration		
e. Measurement Accuracy Merged with Sea Ice Characterization in IORD II				
1. Ice Edge Boundary	10 deg latitude/longitude	5 deg latitude/longitude	10 km	5 km
2. Ice Edge Concentration	20 %	10 %	Greater of 20 % and 1/10	
f. Refresh Merged with Sea Ice Characterization in IORD II	12 hrs	6 hrs		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
3. Net Heat Flux (DoD/DOC)				
a. Sensing Depth	Air / Sea interface	Air / Land / Sea Interface	N/A	N/A
b. Horizontal Cell Size	20 km	5 km		
c. Mapping Uncertainty	7 km			
d. Measurement Range	0 to 2000 $W\ m^{-2}$	0 to 1000 $W\ m^{-2}$	0 to 1000 $W\ m^{-2}$	0 to 2000 $W\ m^{-2}$
e. Measurement Precision	5 $W\ m^{-2}$	1 $W\ m^{-2}$		
f. Measurement Accuracy	10 $W\ m^{-2}$	1 $W\ m^{-2}$		
g. Refresh	6 hrs	3 hrs		
h. Latency			24 hours	6 hours
i. Geographic Coverage			Global Oceans	Global Oceans

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
4. Littoral Sediment Transport (DoD). Deleted from IORD II. Duplicate number..				
a. Horizontal Cell Size, worst case. Deleted from IORD II.	1.3 km	0.1 km		
b. Mapping Uncertainty, worst case. Deleted from IORD II.	3 km	0.1 km		
c. Measurement Precision Deleted from IORD II.	40 %	15 %		
d. Measurement Accuracy Deleted from IORD II.	30 %	15 %		
e. Refresh. Deleted from IORD II.	48 hrs	12 hrs		

SYSTEM CAPABILITIES	IORD I	IORD II

AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
4. Sea Ice Characterization (DOC/DoD)				
a. Vertical Coverage	Ice Surface	1 m		**Ice Surface**
b. Horizontal Cell Size (Ice Concentration)	3 km	0.1 km	20 km	0.05 km
c. Mapping Uncertainty	3 km	1 km	5 km	.05 km
d. Measurement Range				
1. Ice Concentration			1/10 to 10/10	0/10 to 10/10
2. Ice Age	1 to 36+ months		Ice free, multi-year, all other ice	Ice free, Nilas, Grey White, Grey, White, first year medium, first year thick, second year, and multi-year; smooth and deformed ice
2. Ice Motion Deleted in IORD II	TBD	0 to 50 $km day^{-1}$		
e. Measurement Uncertainty				
1. Ice Concentration			1/10	5 %
2. Ice Age (probability of correct typing)			70 %	90 %
f. Refresh	24 hours	12 hours		6 hours
g. Long Term Stability				
1. Ice Concentration			1 %	
2. Ice Edge Motion Deleted in IORD II	1 km per day	0.1 km per day		
h. Latency			8 hours	15 minutes
i. Geographic Coverage			All ice covered regions of the global ocean	All ice covered regions of the global ocean

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
5. Ice Surface Temperature (DOC/DoD)				
a. Sensing Depth	Ice Surface	2 m above ice surface		
b. Horizontal Cell Size			1.0 km at nadir 1.6 km (worst case)	0.1 km
c. Mapping Uncertainty	3 km	1 km	1.0 km at nadir 1.6 km (worst case)	0.1 km
d. Measurement Range	-60 to +20 deg C		213 - 275 K	213 - 293 K (2m above ice)
e. Measurement Uncertainty	1 deg C		1 K	
f. Refresh	24 hrs	12 hours		
g. Latency			90 minutes	15 minutes
h. Geographic Coverage			Oceans and navigable waters associated with the Great Lakes, and Chesapeake and Delaware Bays.	All ice-covered waters

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
6. *Ocean Color (DoD/DOC)*				
a. Horizontal Cell Size				
1. Nadir	2.6 km	1 km	0.75 km	
2. Worst case	1.3 km	0.1 km	1.6 km	0.1 km
b. Mapping Uncertainty				
1. Nadir	3 km	0.5 km	0.75 km	
2. Worst case	3 km	0.1 km	1.6 km	0.1 km
c. Measurement Range	0.01 to 50 mg m^{-3}	0.001 to 100 mg m^{-3}		
1. Ocean Color			0.10-10 W $m^{2} \mu m^{-1} sr^{-1}$	0.05-10 W $m^{2} \mu m^{-1} sr^{-1}$
2. Optical Properties				
a. Absorption			0.01 to 10 m^{-1}	.005 to 20 m^{-1}

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
b. Scattering			0.01 to 50 m^{-1}	.005 to 75 m^{-1}
c. Chlorophyll Fluorescence			N/A	Detectable signal in waters with chlorophyll from 0.1 to 50 mg m^{-3} at 1 km resolution
3. Chlorophyll			0.01 to 50 mg m^{-3}	0.001 to 100 mg m^{-3}
d. Measurement Precision	20 %	10 %		
1. Ocean Color				
a. Operational			5 %	2 %
b. Science Quality			2 %	1 %
2. Optical Properties				
a. Operational			20 %	20 %
b. Science Quality			20 %	10 %
3. Chlorophyll				
a. Operational			20 %	10 %
b. Science Quality			10 %	5 %
e. Measurement Accuracy	30 %	30 %		
1. Ocean Color				
a. Operational			10 %	5 %
b. Science Quality			5 %	3 %
2. Optical Properties				
a. Operational			40 %	30 %
b. Science Quality			30 %	20 %
3. Chlorophyll				
a. Operational			40 %	20 %
b. Science Quality			30 %	10 %
f. Refresh	48 hours	12 hrs	24 hours	12 hours
g. Long Term Stability (W $m^{-2}\mu m^{-1}sr^{-1}$)				
1. At the wavelength of Max chlorophyll absorption			0.5	0.25
2. At the wavelength ofMin chlorophyll absorption			0.25	0.125
3. At the IR wavelength used for Atmospheric Correction			0.08	0.04
h. Latency				
1. Operational			180 minutes	60 minutes
2. Science Quality			48 hours	24 hours

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
7. Sea Surface Height (DOC)/Topography (DoD)				
a. Horizontal Resolution	4 km	0.5 km		
1. Satellite Nadir			15 km	2 km
2. Horizontal Reporting Interval			1 km	0.2 km
3. Closest Point to Shore			10 km	3 km
b. Mapping Uncertainty Deleted in IORD II.	2 km	1 km		
c. Measurement Range Deleted in IORD II	50 m	50 m		
b. Measurement Precision	3 cm	2 cm		
c. Measurement Accuracy	5 cm	3 cm		
1. Mesoscale			6 cm	4 cm
2. Basin Scale			5 cm	3 cm
3. Global Scale			4 cm	2 cm
d. Exact Repeat Period			20 days	10 days
e. Equatorial Track Spacing			≤165 km	≤50 km
f. Latency				
1. Mesoscale			24 hours	3 hours

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
2. Basin Scale			3 days	2 days
3. Global Scale			3 months	2 months
g. Geographic Coverage			66 S to 66 N Latitude	85 S to 85 N
h. Long Term Stability (after calibration)			1 mm per year	0.5 mm per year
f. Refresh Deleted from IORD II.	72 hrs	3 hrs	14 days	

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
8. Ocean Wave Characteristics (DoD/DOC)				
a. Horizontal Cell Size				
1nadir along track	20 km	5 km	2.5 to 20 km (sea state dependent)	2.5 km
2. Regional nadir along track Deleted from IORD II	10 km	0.25 km		
b. Mapping Uncertainty			2 km	0.25 km
1. Global, worst case Deleted from IORD II	10 km	2 km		
2. Regional, worst case Deleted from IORD II	4 km	0.25 km		
c. Measurement Range	height: 0.5 to 30 m direction: 0 to 360 deg Deleted from IORD II	0.5 to 30 m 0 to 360 deg Deleted from IORD II	0.1 to 30 m	0.0 to 30 m
d. Measurement Precision	height: 0.2 m direction: 10 deg Deleted from IORD II	0.1 m 5 deg Deleted from IORD II	Height: 0.2 m or 10 %, whichever is greater	Height: 0.1 m or 10 %, whichever is greater
e. Measurement Accuracy	height: 0.2 m direction: 10 deg Deleted from IORD II	0.2 m 5 deg Deleted from IORD II		
f. Refresh	72 hrs	6 hrs	As available from Altimetry	As available from Altimetry
g. Long Term Stability			N/A	N/A
h. Latency			120 minutes	15 minutes
i. Geographic Coverage			Global, ice-free, ocean, and Great Lakes	Global, ice-free, ocean, and Great Lakes

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
9. Global Sea Surface Wind Stress (DOC/DoD)				
a. Horizontal Cell Size	50 km	20 km	20 km	1 km
b. Mapping Uncertainty	7 km	10 km	5 km	1 km
c. Measurement Range	0 to 50 N m^{-2}	0 to 50 N m^{-2}	0 to 2 N m^{2}	0 to 10 N m^{-2}
d. Measurement Precision	2 N m^{2}	1 N m^{2}	0.02 N m^{-2}	0.01 N m^{-2}
e. Measurement Accuracy	2 N m^{2}	1 N m^{2}	0.02 N m^{-2}	0.01 N m^{-2}
f. Refresh	12 hrs	12 hrs	8 hours	1 hour
g. Long Term Stability			N/A	N/A
h. Latency			90 minutes	15 minutes
i. Geographic Coverage			Global Ocean	Global Ocean

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.6.x - Ocean/Water Parameters				
11. Mass Loading (DoD/DOC)Deleted from IORD II.				
a. Sensing Depth Deleted from IORD II.	Surface	TBD		
b. Horizontal Cell Size Deleted from IORD II.	1.3 km	0.25 km		
c. Mapping Uncertainty Deleted from IORD II	TBD	0.5 km		
d. Measurement Range Deleted from IORD II	TBD	0 to 100 mg l^{1}		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.6.x - Ocean/Water Parameters				
e. Measurement Precision Deleted from IORD II	TBD	0.1 mg l^{-1}		
f. Measurement Accuracy Deleted from IORD II	30 %	0.1 mg l^{-1}		
g. Refresh Deleted from IORD II	48 hrs	24 hrs		

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.7.x - Space Environmental Parameters				
1. Auroral Boundary (DoD/DOC)				
a. Measurement Uncertainty	50 km	10 km	100 km	10 km
b. Latency			90 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.7.x - Space Environmental Parameters				
2. Auroral Energy Deposition (DoD/DOC)				
a. Measurement Range	electrons: 10^{-4} to 1 W m^{-2}	electrons: $5x10^{-5}$ to 1 W m^{-2}		
1. Energy Flux			10^{-4} to 1 W m^{-2}	$5x10^{-5}$ to 1 W m^{-2}
2. Mean Energy	ions: 10^{-4} to 10^{-1} W m^{-2}	ions: $5x10^{-5}$ to 10^{-1} W m^{-2}	100 eV to 20 keV	30 eV to 30 keV
b. Measurement Uncertainty	Greater of 20 % or 10^{-4} W m^{-2}	Greater of 10 % or $5x10^{-5}$ Wm^{-2}	Greater of 20 % or 10^{-4} W m^{-2}	Greater of 10 % or $5x10^{-5}$ W m^{-2}
c. Latency			90 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.7.x - Space Environmental Parameters				
3. Auroral Imagery (DoD/DOC)				
a. Measurement Range	120 to 180 nm	80 to 250 nm	Moderate to very active aurora	Quiet to very active aurora
b. Measurement Uncertainty	10 %	5 %	10 %	5 %
c. Horizontal Cell Size	20 km	10 km	100 km	10 km
d. Latency			90 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.7.x - Space Environmental Parameters				
4. Electric Field (DoD/DOC)				
a. Measurement Range	0 to 150 mV m^{-1}	0 to 250 mV m^{-1}	0 to ± 150 mV m^{-1}	0 to ± 250 mV m^{-1}
b. Measurement Precision	2.0 mV m^{-1}	0.1 mV m^{-1}		
c. Measurement Uncertainty	3.0 mV m^{-1}	0.1 mV m^{-1}	3.0 mV m^{-1}	0.1 mV m^{-1}
d. Latency			90 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.7.x - Space Environmental Parameters				
5. Electron Density Profile (DoD/DOC)				
a. Horizontal Cell Size				
1. 0 - 30 deg lat	200 km	100 km	100 km	10 km

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.7.x - Space Environmental Parameters				
2. 30 - 50 deg lat	500 km	250 km		
3. 50 - 90 deg lat	100 km	50 km	50 km	10 km
b. Vertical Cell Size				
1. 90 to 500 km	10 km	5 km		3 km
2. > 500 km	20 km	5 km		
c. Vertical Coverage			90 km to Satellite Altitude	90 to 1600 km
d. Measurement Range				
1. Density, n_e	$3x10^5$ to 10^7 cm^{-3}	10^4 to 10^7 cm^{-3}	$2.5x10^4$ to 10^7 cm^{-3}	
2. TEC vertical	$3x10^{16}$ to $2x10^{18}$ m^{-2}	10^{16} to $2x10^{18}$ m^{-2}	3 to 200 TEC units	1 to 200 TEC units
3. foF2	5 to 30 MHz	1 to 30 MHz		
4. Ion Composition				O_2^+, NO^+, O^+, H^+, He^+
e. Measurement Uncertainty				
1. Density, n_e	± $3x10^5$ cm^{-3}	± 10^4 cm^{-3}	Greater of 10^5 cm^3 or 30 %	Greater of 10^4 cm^3 or 5 %
2. TEC, vertical	± 20 %	± 5 %	Greater of 3 TECU or 30 %	Greater of 1 TECU or30 %
3. Features:				
a. h_mF_2			20 km	5 km
b. n_mF_2 (cm^3)			20 %	10 %
c. n_mE (cm^{-3})	± 20 km	± 5 km	20 %	5 %
d. ion composition. Deleted from IORD II.	Greater of ± 20 % or $3x10^{16}$ m^{-2}	± 10^{16} m^{-2}		
4. Composition Discrimination				5 % of local density
f. Latency			90 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.7.x - Space Environmental Parameters				
6. Geomagnetic Field (DoD)				
a. Horizontal Reporting Interval			1 km	0.1 km
b. Horizontal Cell Size	10 km	0.5 km	100 m	100 m
c. Measurement Range	3D mag vector at s/c	3D mag vector at s/c	0 to ± 60,000 nT	0 to ± 60,000 nT
d. Measurement Precision	2 nT	0.5 nT	30 nT (per axis) 5 nT (per axis)	30 nT (per axis) 2 nT (per axis)
e. Measurement Uncertainty. Deleted from IORD II.				
1. Magnitude Deleted from IORD II	6 nT(rms)	2 nT		
2. Vector direction	1.0 arc min	0.6 arc min		
f. Latency			90 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I Thresholds	IORD I Objectives	IORD II Thresholds	IORD II Objectives
Para 4.1.6.7.x - Space Environmental Parameters				
7. In-Situ Plasma Fluctuations (DoD/DOC)				
a. Horizontal Reporting Interval	100 km	5 m		50 km
b. Measurement Range				
1. Spectral Index	2 to 5	1 to 10	1 to 5	1 to 5
2. ?n/n	10^{-2} to 1.0	10^{-4} to 1.0		10-2 to 1.0
c. Measurement Uncertainty				
1. In-situ Density			Greater of 20% or 5x 104 cm -3	Greater of 5% or 2x 102 cm-3
d. Latency			90 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	Objectives	Thresholds	Objectives
Para 4.1.6.7.x - Space Environmental Parameters				
8. In-Situ Plasma Temperature (DoD/DOC)				
a. Horizontal Reporting Interval	100 km	10 km		
b. Measurement Range	500 to 10,000 K	500 to 10,000 K		
c. Measurement Uncertainty	10 %	5 %		
d. Latency			90 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	**IORD I**		**IORD II**	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.7.x - Space Environmental Parameters				
9. Ionospheric Scintillation (DoD)				
a. Horizontal Cell Size	100 km	50 km		25 km
b. Measurement Range				
1. Amplitude Index (S4)	0.1 to 1.5			0.1 to 1.5
2. Phase Index (s)	0.1 to 20 radians			0.1 to 30 radians
c. Measurement Precision				
1. Amplitude Index (S4)	0.1			0.1
2. Phase Index (s)	0.1 radians			0.1 radians
d. Measurement Accuracy	Factor of 2			
e. Latency			90 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	**IORD I**		**IORD II**	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.7.x - Space Environmental Parameters				
10. Neutral Density Profile (DoD/DOC)				
a. Vertical Coverage	100 to750 km	90 to 1600 km	90 km to Satellite Altitude	
b. Horizontal Cell Size	500 km	50 km		250 km
c. Vertical Cell Size				
1. Up to 120 km	10 km	0.5	5 km	
2. Above 120 km	10 km	3 km	5 km	
d. Measurement Range				
1. Atmospheric density	$3x10^{-9}$ to $2x10^{-19}$ g cm^{-3}		$8.5x10^{-18}$ to $5x10^{-9}$ g cm^{-3}	$2x10^{-19}$ to $5x10^{-9}$ g cm^{-3}
2. Number density	$9x10^{4}$ to $6x10^{13}$ cm^{-3}		10^{6} to $6x10^{13}$ cm^{-3}	$9x10^{4}$ to $6x10^{13}$ cm^{-3}
3. Neutral Composition				N_2, O_2, O, He, H
e. Measurement Uncertainty				
1. < 500 km	15 %	5 %	10 %	
2. 500 to 700 km	20 %	10 %	15 %	
3. > 700 km	20 %	15 %		
f. Latency			90 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	**IORD I**		**IORD II**	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.7.x - Space Environmental Parameters				
11. Medium Energy Charged Particles (DoD/DOC)				
a. Measurement Range				
1. Energy				
Ions	ions: 30 keV to 10 MeV in 8 bands		50 keV to 10 MeV in 6 bands	50 KeV to 10 MeV in 6 bands
Electrons	electrons: 30keV to 10 MeV in 8 bands		50 keV to 4 MeV in 5 bands	50 KeV to 4 MeV in 5 bands
2. Total Flux			10^{6} to $5x10^{11}$ m^{-2} s^{-1} str^{-1}	$5x10^{5}$ to $2x10^{12}$ m^{-2} s^{-1} str-1
Ions. Deleted from IORD II	10^{5} to 10^{11} $m^{-2}s^{-1}str^{-1}$			
Electrons. Deleted from IORD II	10^{5} to 10^{11} m^{-2} $s^{-1}str^{-1}$			
b. Measurement Precision	5 %	1 %	Greater of 10^{6} m^{-2} $s^{-1}str^{-1}$ or 5 %	Greater of 10^{5} m^{-2} s^{-1} str^{-1} or 1 %
c. Measurement Accuracy	20 %	10 %	15 %	10 %

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.7.x - Space Environmental Parameters				
d. Latency			90 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.7.x - Space Environmental Parameters				
12. Energetic Ions(DoD/DOC)				
a. Measurement Range				
1. Energy p^+	protons: >10 MeV to 1000 MeV/nucleon in 6 bands	protons: >10 MeV to >1000 MeV/nucleon in 8 bands	10 MeV to 300 MeV in 4 bands	10 MeV to 400 MeV in 5 bands
2. Flux				
p^+ <100 MeV	protons: 10^3 to 10^{10} $m^{-2}s^{-1}str^{-1}$	protons: 10^2 to 10^{10} $m^{-2}s^{-1}str^{-1}$	$5x10^3$ to $2x10^9$ $m^{-2}s^{-1}$ str^{-1}	$5x10^3$ to $2x10^9$ $m^{-2}s^{-1}$ str^{-1}
P^+ >100 MeV			10^3 to $3x10^8$ $m^{-2}sec^{-1}$ str^{-1}	10^3 to $3x10^8$ $m^{-2}s^{-1}$ str^{-1}
3. Linear Energy Transfer (Heavy Ions)				0.1 to 100 MeV cm^2 mg^{-1}
b. Measurement Precision (flux)				
p^+ <100 MeV	5%	1%	Greater of $5x10^3$ $m^{-2}sec^{-1}$ $ster^{-1}$, or 5 %	Greater of $5x10^3$ $m^{-2}s^{-1}$ str^{-1}, or 1 %
p^+ >100 MeV			Greater of 10^3 $m^{-2}s^{-1}$ str^{-1}, or 10 %	Greater of 10^3 $m^{-2}s^{-1}$ str^{-1}, or 2 %
c. Measurement Accuracy (flux)				
p^+ <100 MeV	±20%	±10%	Greater of $5x10^3$ $m^{-2}s^{-1}$ str^{-1}, or 20 %	Greater of $5x10^3$ $m^{-2}s^{-1}$ str^{-1}, or 10 %
p^+ >100 MeV			Greater of 10^3 $m^{-2}s^{-1}$ str^{-1}, or 10 %	Greater of 10^3 $m^{-2}s^{-1}$ str^{-1}, or 2 %
d. Latency			90 minutes	15 minutes

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.7.x - Space Environmental Parameters				
13. Supra-thermal through Auroral Energy Particles (DoD/DOC)				
a. Measurement Range				
1. Energy	30 eV to 30 keV		30 eV to 50 keV	30 eV to 50 keV
2. Differential Dir. Energy Flux	10^8 to 10^{15} $m^{-2}s^{-1}str^{-1}keV^{-1}$			
i. Electrons			10^9 to 10^{14} $m^{-2}s^{-1}str^{-1}$	10^9 to 10^{14} $m^{-2}s^{-1}str^{-1}$
ii. Ions			10^9 to 10^{13} $m^{-2}s^{-1}str^{-1}$	10^9 to 10^{13} $m^{-2}s^{-1}str^{-1}$
b. Measurement Precision. Deleted in IORD II				
1. Energy	?E/E = 20 %	?E/E = 10 %		
2. Flux	5 %	1 %		
b. Measurement Accuracy				
1. PassB and Center Energy			2 %	2 %
2. Dif. Dir. Energy Flux	20 %	10 %	Greater of 10^9 $m^{-2}s^{-1}$ str^{-1}, or 15 %	Greater of 10^9 $m^{-2}s^{-1}$ str^{-1}, or 15 %
c. Latency			90 minutes	15 minutes
d. Measurement Uncertainty				
1. Particle Energy			20 %	15 %

SYSTEM CAPABILITIES AND CHARACTERISTICS	IORD I		IORD II	
	Thresholds	**Objectives**	**Thresholds**	**Objectives**
Para 4.1.6.7.x - Space Environmental Parameters				
14. Neutral Wind (Objective EDR). Moved to P3I in IORD II.	*Threshold*	*Objective*	*Threshold*	*Objective*
a. Horizontal Cell Size. Moved to P3I in IORD II.	250 km	250 km		
b. Vertical Cell Size. Moved to P3I in IORD II.	3 km	3 km	15km	15km
c. Horizontal Coverage. Moved to P3I in IORD II.	Global	Global		
d. Vertical Coverage. Moved to P3I in IORD II.	90 to 500 km	90 to 500 km		
e. Measurement Range. Moved to P3I in IORD II.	0 to ± 1500 m s^{-1}	0 to ± 1500 m s^{-1}		
f. Measurement Uncertainty. Moved to P3I in IORD II.	Greater of 5 m s^{-1} or 5 %	Greater of 5 m s^{-1} or 5 %		
g. Latency	90 minutes	15 minutes		

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Requirements Correlation Matrix (RCM)
RCM Part II
(Supporting Rationale for System Characteristics and Capabilities)

NOTE: The agency listed first (DOC or DoD) has the more stringent requirements. "AWS Report" refers to the AWS report Use of Polar-orbiting Meteorological Satellite Data by Air Force Weather. "Navy Requirements Review" refers to the Navy study Meteorology and Oceanography Satellite Remote Sensing Requirements of the United States Navy and Marine Corps and subsequent requirements reviews for DMSP Block 6, NPOESS, Geosat Follow-on and WindSAT.

System Characteristics (Para 4.1.5)

Parameter 1-- Data Latency and Availability (DoD/DOC). (USAF) Data availability values are based on perishability of weather data as documented in HQ USAF/XOWX memo, 3 Mar 95, National Agenda for Meteorological Services and Supporting Research which states how meteorological data value, for predictive purposes, diminishes exponentially with time. Failure to meet threshold values would result in degraded support to National Program customers whose requirements for polar-orbiting satellite derived products are documented in National Program Requests for Environmental Support (RES) and Interface Control Documents (ICDs) on file at Headquarters Air Force Weather Agency (HQ AFWA).

(DOC) DOC requires time-continuous measurements of atmospheric, oceanic, and land-surface parameters to ensure successful analyses for environmental prediction missions. Coverage gaps critically degrade utility of high-resolution measurements for real time prediction and climatological missions.

Parameter 2--Autonomous Operations (DoD). (USAF) DoD requires continuing data transmissions during contingencies or conflicts, even when the C^3 segment is down. The threshold values were established as a result of AFSPC evaluations in determining the amount of time required to reconstitute the C^3 segment using redundant assets.

Parameter 3--Surface Data Collection (DOC/DoD). (DOC) DOC requirement for ARGOS system payload covered by Memorandum of Understanding between National Oceanic and Atmospheric Administration and the Centre National D'Etudes Spatiales for the ARGOS Data Collection and Platform Location System; effective beginning 26 March 1986. US Navy also will require ARGOS capability.

Parameter 4--Orbital Characteristics (DoD/DOC). (USAF) Requirements specified in classified documents maintained at HQ AFWA identify the need for required orbital characteristics.

(DOC) DOC requires observations from NPOESS in sun-synchronous, early afternoon (around 1330L equatorial crossing time) orbit to maximize availability of meteorological, oceanic, and surface measurements over the areas of the globe most critical to numerical weather prediction model initialization for the United States. (Scientific assessment -- National Centers for Environmental Prediction.)

Parameter 5--Orbital Characteristics for Sea Surface Height Measurement (DoD). (USN) requires repeat ground track to support ocean circulation models and products.

Parameter 6--System Survivability (DoD). See IORD Attachment 2.

Parameter 7--Search and Rescue (DOC). (DOC) DOC operates this system under guidelines of a memoranda of agreement with the governments of France, Russia, and Canada: (1) International COSPAS-SARSAT Program Agreement (1 July 1988), Russia, Canada, France, and U.S. (2) International SARSAT Memorandum of Agreement (5 September 1995), Canada, France, and U.S. (3) Memorandum of Understanding among the National Oceanic and Atmospheric Administration, U.S. Coast Guard, U.S. Air Force, and NASA Regarding the United States Responsibilities Relating to the U.S. COSPAS-SARSAT System (23 September 1991).

Parameter 8--Compatibility (DOC). DOC depends on remote-sensing expertise exchange through cooperative institutes with several universities and other civilian agencies who gather POES data directly. Further, DOC has fostered private-sector markets for polar-orbiting satellite image receiving and processing systems. Evolution to next-generation ground processing systems for NPOESS shall be manageable and non-disruptive to these efforts where economical and practical.

Parameter 9--Space Debris Minimization (DoD/DOC). These requirements are IAW National Space Policy Directive 1, dated 19 Sep 1996, UPD 1039 and NASA Safety Standard 1740.14.

Parameter 10--*Data Access (*DoD). (USAF) DoD operational security (OPSEC) regulations direct the control of data generated by DoD systems that could be used against our operational forces. Presidential Decision Directive/NSTC-2, 5 May 94, requires data denial capability on NPOESS.

(USA) CJCSI 3810.01, “Meteorological and Oceanographic Operations”, Jan 95, establishes need to selectively deny data to potential adversaries while retaining access for U.S. forces.

Parameter 11--*Interoperability (*DoD). NPOESS system interfaces shall be interoperable with the systems with which they must communicate. This includes the physical and electrical interfaces with equipment at the Centrals and Field Terminals, and the RF interfaces to various DoD and civilian nodes.

Parameter 12--Geolocation of Data (DOC/DoD). (DOC) NPOESS satellite orbit and attitude information shall be provided with the sensor data so the USG or other users can assign a specific Earth location to any measurement or observation. Such Earth location information is required in order to be able to correctly process quantitative data into mapped values, and to co-locate measurements with measurements from other space-based or in situ sensors.

(USAF) This is an Air Force Weather requirement which will allow their Small Tactical Terminal (STT) users to use a GPS reference grid to determine location of cloud features and other data received from NPOESS. Documentation of this requirement may be found in the STT Concept of Operations (CONOPS).

Parameter 13--Space Environmental Constellation Characteristics (DoD/DOC). The full set of Space Environmental EDRs should be measured in each available orbital plane at the specified resolutions and coverage (DoD/DOC). Equally-spaced sampling, including measurements near the dawn/dusk terminator and the noon/midnight plane, is needed to support global specification and forecast models (DoD). The latency system capability for the Space Environmental EDRs addresses the needs of Space Weather operators for real- time product generation [less than or equal to 15 min] and for post-event analyses [less than or equal to 90 min] (DoD/DOC). DoD-derived requirements for geomagnetic field place a higher degree of fidelity on the measurement accuracy [5 nT] than on the measurement precision [30 nT] (DoD). DOC and other secondary DoD requirements for geomagnetic field place a moderate degree of fidelity on measurement precision (30 nT is adequate) with no specific requirements on measurement accuracy (DOC/DoD). The stressing geomagnetic field requirement for the DoD can be accommodated in 1 orbital plane (1330A preferred) with no specific requirement on latency [24 hours is more than adequate] (DoD).

Key Environmental Data Records (Para 4.1.6.1)

Parameter 1--*Atmospheric Vertical Moisture Profile (*DOC/*DoD). (USAF) Atmospheric profiles of moisture from space-based platforms are required at the specified threshold values as documented in AWS Report.

(USN) Navy Requirements Review concluded atmospheric profiles of moisture from polar-orbiting satellites are required at the specified threshold values to initialize the Navy's emerging high-resolution global air/ocean models. These models provide the global meteorological and oceanographic predictions to the Fleet and other military services and provide the boundary conditions for both the regional and tactical models which support specific warfare areas and weapons systems tactical decision aids. Much of the atmospheric moisture is concentrated close to the Earth's surface, in the lowest 1 to 2 km of the atmosphere. Comparisons of Navy model simulations indicate if the measurement accuracies of the profiles are less than the threshold values, the profile data corrupts the model rather than increasing its capability to forecast. Observational errors, usually on the smaller scales, amplify and through nonlinear interactions gradually spread to the longer scales, eventually destroying forecast skill. In previous studies, numerical models using data with a standard deviation of 0.5°C at all levels had an exponential error growth with a doubling time of about 2.5 days. Similar results were found for other data types (i.e., winds, moisture, etc.), with forecast errors as high as 20 to 30%. Navy model simulations show a one to three day improvement in forecast ability in the data sparse Southern hemisphere.

(DOC) The National Centers for Environmental Prediction (NCEP) scientific assessment and "NOAA Requirements for Support from Polar-Orbiting Spacecraft," identifies model initialization and data assimilation requirements which drive vertical Reporting interval, mapping uncertainty and refresh rate values consistent with specified threshold requirements. Results from the AGU Chapman Conference on Water Vapor in the Climate System, 25-28 October 1994 indicate DOC requires measurement accuracies better than specified threshold requirements in order to achieve any improvements in NOAA's regional model three hour forecast.

Parameter 2--*Atmospheric Vertical Temperature Profile (*DOC/ *DoD). (USAF) Atmospheric profiles of temperature from space-based platforms are required at the specified threshold values as documented in AWS Report.

(USN) Navy Requirements Review concluded atmospheric profiles of temperature from polar-orbiting satellites are required at the specified threshold values to initialize the Navy's emerging high-resolution global air/ocean models. These models provide the global meteorological and oceanographic predictions to the Fleet and other military services and provide the boundary conditions for both the regional and tactical models which support specific warfare areas and weapons systems tactical decision aids. Comparisons of Navy model simulations indicate if the measurement accuracies of the profiles are less than the threshold values, the profile data corrupts the model rather than increasing its capability to forecast. Observational errors, usually on the smaller scales, amplify and through nonlinear interactions gradually spread to the longer scales, eventually destroying forecast skill. In previous studies, numerical models using data with a standard deviation of 0.5°C at all levels had an exponential error growth with a doubling time of about 2.5 days. Similar results were found for other data types (i.e., winds, moisture, etc.), with forecast errors as high as 20 to 30%. Navy model simulations show a one to three day improvement in forecast ability in the data sparse Southern hemisphere.

(DOC) The National Centers for Environmental Prediction (NCEP) scientific assessment and "NOAA Requirements for Support from Polar-Orbiting Spacecraft," identifies model initialization and data assimilation requirements which drive vertical reporting interval, mapping uncertainty and refresh rate values consistent with specified threshold requirements. The National Weather Service Technical Procedures Bulletin No. 422 describes the 6 hr forecast error at 500 mb, vs. radiosondes, from 1979 to 1991 as decreasing from 1.8 K to about 1.4 K over this period. As of 2000 this error has decreased to 1.0K. The satellite retrieval shall be better than the 6 hour forecast fit to radiosonde data to be useful, therefore DOC desires measurement accuracies exceeding specified threshold requirements.

Parameter 3--*Sea Surface Winds (Speed and Direction) (*DoD/*DOC). (USAF) As stated in AWS Report, wind speed data at the specified values are needed as inputs to prepare tropical cyclone warnings, to derive sea state, and for use in ship and aircraft routing, flight safety, and other operations, such as NBC dispersions.

(USN) Navy Requirements Review concluded skill in sea surface wave forecasting depends heavily on the skill of predicting sea surface winds. At 20 km horizontal increments and 6 hours refresh, sea surface winds from a polar-orbiting weather satellite with a measurement accuracy of +/-2 m s^{-1} or +/- 10% (whichever is higher) will yield open ocean wave heights within an error of 10-20% and wave energy within 20-50%. This provides wind and wave data within the critical/narrow values for Precision Guided Munitions (i.e., Tomahawk), amphibious landing craft operations, naval facilities located in low lying coastal areas (i.e., hurricane/flooding) and aircraft safety and recovery during aircraft carrier flight operations.

(DOC) DOC requires a horizontal resolution of 25 km, based on operational experience and our projected requirements for future numerical weather prediction models. (See citation summary, below.) DOC requires sufficient accuracy and sensitivity to allow retrieval of the ocean surface wind speed to +/- 2 ms^{-1} or 10%, whichever is greater, and carries a wind direction attribute objective of +/-20 degrees, to meet the modeling requirements of the National Meteorological Center. These values are based on conclusions from the following citations: O'Brien, James J. et al., "Scientific Opportunities Using Satellite Wind Stress Measurements over the Ocean, Report of the Satellite Surface Stress Working Group," NASA Technical Report, 1982; Burpee, Richard A., *Memorandum: Military requirements for Defense Environmental Satellites*, MJCS 154-86, 1986; Hooper, Nancy and John W. Sherman III, *1986*, *Temporal and Spatial Analysis of Civil Marine Satellite Requirements*, *NOAA Technical Report NESDIS 16*, U.S. Department of Commerce; Jet Propulsion Laboratory, *Ocean Services User Needs Assessment*, Tech. Report, NOAA, 1984; Sullivan, Kathryn (chairperson), 1993, *NOAA-DOD-NASA Tri-Agency Polar Requirements Summary*, *NOAA.*)

(DOC/USN Ocean Observer Requirements Team) These are measurements of ocean surface wind speed day and night under all weather conditions except in the presence of integrated rainfall rates greater than 2 mm $hr^{-1}km^{-2}$ (only 5% of the ocean has rainfall rates greater than 2 mm $hr^{-1}km^{-2}$). Operational requirements for NOAA's short-term forecasting and warning responsibilities require knowledge of the ocean surface winds in adverse weather conditions as well as clear sky conditions. The wind retrieval measurement performance requirements are to be levied on the 10 meter height neutral stability winds (i.e., the wind that would be measured by an anemometer at a height of 10 meters). Under conditions of significant non-neutral boundary layer stratification, the 10 meter neutral stability winds may differ measurably from the winds that would be directly measured by an array of anemometers at a 10 meter height.

Constraining biases to 25% of the measurement uncertainty allows these winds to be used for climate purposes where large biases are often worse than large variance. Wind measuring instruments often measure wind direction with one or more ambiguities or uncertainties in direction. To insure useful direction information, the measurement uncertainty specifications for direction shall be applied to the unique chosen ambiguity (i.e., that direction chosen as the most likely of the possible directions). The closest ambiguity to the ground truth wind direction should not be used for validation of the wind direction unless the total number of ambiguities is restricted to 4 or less.

Parameter 4--*Imagery (DoD/DOC). (USAF) Threshold values are those required for weather model inputs and to provide field forecasters with clarity required for adequate forecast accuracy as documented in AWS Report. A global refresh threshold of 2 hours (1 hour objective) is essential to support the above requirements. This 2-hour refresh requirement is driven by the need to provide data with sufficient timeliness to be used as input into Tactical Decision Aid software models. Additionally, these accurate forecasts are needed for battlespace situational awareness as part of the Chairman, Joint Chiefs of Staff's Joint Vision 2020 operational concept for Precision Engagement. Without precise forecasts, the ability of joint forces to locate, surveil, discern and track objectives or targets will be limited. Air Combat Command Global Attack Mission Area Plan, FY 2002 also cites this as an important mission area – the ability to deliver weapons precisely and effectively under all weather conditions while minimizing collateral damage. Without timely imagery, this mission will be substantially degraded. This imagery data is also used as input into the future Cloud Depiction and Forecast System-2 (CDFS-2) operated by the AFWA. This two-hour requirement is based on hourly global analyses and forecasts to provide customer support. Geostationary satellite data provide adequate imagery, albeit degraded compared to polar satellite resolution, for areas equatorward of 45 degrees at refresh rates varying between 5 minutes and one hour. Data from these satellites are limited poleward of 45 degrees due to degradation in resolution, radiometric accuracy (caused by increased atmospheric slant path), geolocation of cloud features, and cloud identification. These limitations make it necessary to use polar-orbiting satellite data poleward of 45 degrees and to supplement the global database equatorward of 45 degrees. This latitude was selected based on the extent of coverage yielded by the location and spacing of the five geostationary satellites described by the World Meteorological Organization agreement of 1967. This geostationary constellation results in gaps in quantitatively useful data poleward of 45 degrees. The "Defense Meteorological Satellite Program (DMSP) Tactical Enhancement Analysis/Navy Final Report" (14 May 1993) illustrates significant cost savings based on a regional-scale conflict of a duration similar to Desert Storm, if 6 hour refresh is used with emphasis on E-O weapons. Thunderstorms have lifetimes of approximately one hour or less, thus the objective, allowing the capability to forecast development, growth, speed, and decay of thunderstorms. A cost-performance trade forces a refresh rate longer than one hour. USAF has relaxed this to a 4 hour refresh Threshold requirement in RCM Part I for this parameter due to cost-performance trades and the 2 hour Objective refresh requirement better reflects the realistic need.

(USN) Navy Requirements Review concluded a 4 hour refresh is required to adequately represent the time scale of the weather having the most significant impact on Carrier strike, amphibious and special warfare operations. It also concluded operations during the Persian Gulf and Bosnia conflicts demonstrated weather can change hourly. Imagery provides the qualitative means of analyzing weather on the horizontal (1 km/global, 0.4/regional) and temporal scales (4 hours) having significant impact on mission planning, aircraft operation, weapon delivery/loadout and Battle Damage Assessment. USN has relaxed the Threshold requirement (specifically for the microwave imagery and other EDRs requiring CMIS data) to a 6 hour refresh in RCM I for this parameter due to cost-performance trades and the 4 hour Objective refresh requirement reflects the realistic need for visible and IR imagery.

(DOC) Imagery thresholds are based on values required to support cloud properties, aerosol, and sea surface temperature products as validated in Aug, Sep, and Oct 1995, by NOAA Product Oversight Panels on Calibration, Oceans, Land, and Image-Cloud-Aerosol. The requirement for mapping accuracy of 1 km has been a stated requirement of the NOAA CoastWatch program for the last decade and is required to support mapping of Sea Surface Temperature digital imagery.

List 1
Environmental Measurements Derived from Imagery

Atmospheric Parameters	Land Parameters
	Soil Moisture
Cloud Parameters	Land Surface Temperature
Cloud Cover	Vegetation Index
Optical Thickness	Snow Cover
Cloud Top Height	Surface Type
Cloud Top Temperature	
	Ocean Parameters
Aerosol Particle Size	Sea Surface Temperature
Atmospheric Suspended Matter	Ice Surface Temperature
	Net Heat Flux
Earth Radiation Budget Parameters	Ocean Color
Absorbed Solar Radiation	Sea and Lake Ice
Albedo	Concentration/Age/Motion/Edge Location

List 2
Environmental Phenomena Characterized by All-weather Imagery

Atmospheric Parameters	Land Parameters
Tropical Cyclone Location	Soil Moisture
Convection/rain Patterns	Snow Cover
	Surface Type
Ocean Parameters	Flooded Areas
Sea Surface Temperature	
Sea Ice Characteristics	

Parameter 5--*Global Sea Surface Temperature (*DOC/*DoD). (USAF) The requirements for the stated thresholds are documented in AWS Report.

(USN) Navy Requirements Review concluded sea surface temperature details (i.e., frontal analysis) can be taken into proper consideration only by emerging high-resolution models using a polar-orbiting weather satellite. Horizontal resolutions of 4 km (global) and 1 km (regional) and a measurement accuracy of 0.5^{o} C specify the resolution and accuracy needed. In addition, these resolution and accuracy requirements are needed to bound detection and accuracy parameters for emerging shallow water antisubmarine warfare systems.

(DOC) A regional resolution of at least 3 km at nadir (global resolution) and 1 km (0.25 km Objective) (regional resolution) is required to support coastal management missions within DOC, as described by *NOAA Requirements for Support from Polar Orbiting Satellites, NOAA, DOC,* June 1990, and in *NOAA-DOD-NASA Tri-agency Polar Requirements Summary, NOAA,* 1993. In order to be able to discern thermal details in bays and estuaries for analyses of coastal dynamics, human health, ecosystem sustainability, and resource management, this high-resolution capability is key.

(DOC/USN Ocean Observer Team) An all-weather SST is needed to provide updates for areas which are seasonally cloud covered. Areas in the EEZ off the coast of Washington and Oregon coasts are not imaged with traditional satellite SST sensors for weeks at a time due to persistent stratus cloud cover, necessitating an all-weather solution. Although the need to Absolute SST still exists for these areas, the all-weather capability of a Passive Microwave Sea Surface Temperature will still assist both civil and military applications.

Parameter 6--*Soil Moisture (*DoD/DOC). (USAF) Data at the specified threshold values are required to derive optical and infrared characteristics of the earth's surface for E-O weapon systems support, determining state of ground for trafficability forecasts and mine placement and detection, and as input to stream flow analysis (used for river crossing, dam volume capacity and Agriculture Meteorological (AGRMET) models) as stated in AWS Report. The objective values are established by Army Field Manual 34-81-1, by FM 100-27/FM 4-61/AFM 2-50, and by the Concept Paper for US Army Tactical Weather and Environmental Data Requirements (Oct 91).

(USA) IAW Army FM 34-81-1, 23 Dec 92, Army FM 100-27, and the Concept Paper for US Army Tactical Weather and Environmental Data Requirements, Oct 91, measurements of soil moisture are required to assess the ability for movement of tanks, self-propelled artillery, and other tactical vehicles. The skin layer of soil is determined to be 0.1 cm. Moisture in the surface to 5 cm depth is important to determine surface traction. Moisture at 5 to 10 cm depth impacts cross country vehicle speed. Moisture in the 10 to 30 cm depth can impact trafficability when more than one tank is crossing the same terrain. Trafficability of large-scale operations is impacted with moisture in the 30 to 80 cm depth range. Refresh rate shall be sufficient to detect microscale to mesoscale weather features.

(DOC) A National Centers for Environmental Prediction Scientific Assessment by K. Mitchell has determined the NCEP Eta model requires soil moisture to properly calculate the energy fluxes at the surface. To support this model, DOC requires measurements at the surface with a horizontal resolution of 50 km, mapping uncertainty of 3 km and measurement accuracy of ±10 cm of water per one meter column of soil. Short-term rainfall variability demands a refresh of 8 hours to avoid false characterization of surface moisture in model initialization, according to the NCEP Scientific Assessment.

Atmospheric Parameters (Para 4.1.6.2)

Parameter 1--Aerosol Optical Thickness (DOC/DoD). (USAF) AWS Report establishes aerosol optical thickness threshold values required to provide useful measurements to support PGM employment.

(DOC) This EDR is derived from imagery and threshold values are consistent with values specified in the imagery parameter.

Parameter 2--Aerosol Particle Size (DOC/DoD). (USAF) AWS Report establishes aerosol particle size information at the specified values crucial to precision guided munitions (PGM) support.

(DOC) This EDR is derived from imagery and threshold values are consistent with values specified in the Imagery parameter.

Parameter 3--Aerosol Refractive Index, Single-scattering Albedo, and Shape (DOC). (DOC) Aerosols play a major role in forcing climate change via both cooling and warming; presently they pose the largest uncertainty in the Intergovernmental Panel for Climate Change (IPCC) assessments of global change. Requirements are the result of consensus among NOAA, NASA, and other experts, and are consistent with findings and recommendations of the IPCC and several academy reports.

Parameter 4--Ozone Total Column/Profile (DoD/DOC). (DOC) All threshold values for ozone total column/profile are based on national climate requirements as detailed in Summary Report – Workshop on NPOESS Ozone Measurements Requirements, August 30-31, 1993.

(DoD) Operational measurements of stratospheric ozone are needed at FNMOC to improve DoD operational numerical weather prediction and to support DoD requirements for depiction of the upper atmosphere.

Parameter 5--Precipitable Water/Integrated Water Vapor (DOC/DoD). (DOC) This EDR is derived from imagery, atmospheric sounding data, and microwave observations. DOC threshold requirements are consistent with values specified under parameters of Atmospheric Vertical Moisture Profile, Atmospheric Vertical Temperature Profile, Imagery, Sea Surface Winds, and Soil Moisture, respectively.

(USN) Navy Requirements Reviews and current operational modeling have validated Integrated Water Vapor (IWV) as an important parameter for numerical weather prediction. IWV in particular provides a bound for determining error in water vapor profiles in Navy Global and Mesoscale models.

Parameter 6--Precipitation (Type, Rate) (DoD/DOC). (USAF) Precipitation information at specified values is required to determine the effects on communications, air operations, reconnaissance systems, weapons delivery, field engineering activities and surveillance systems. Threshold values are established in AWS Report.

(DOC) This EDR is derived from imagery, atmospheric sounding data, and microwave observations. DOC threshold requirements are consistent with values specified in parameters for Atmospheric Vertical Moisture Profile, Atmospheric Vertical Temperature Profile, Imagery, Sea Surface Winds, and Soil Moisture.

Parameter 7--Pressure (Surface/Profile) (DoD). (USAF) Pressure profiles are required for high-precision targeting of naval and Army artillery gunfire and ballistic missiles at specified threshold values as documented in AWS Report.

Parameter 8--Suspended Matter (DoD/DOC). (USAF) AWS Report establishes the system capabilities values required to determine the effects of suspended matter on military operations.

(DOC) Volcanic ash plumes are a threat to civil aviation. DOC participates in a civil aviation warning system for volcanic ash hazards by monitoring these plumes in satellite imagery. DOC also monitors smoke from large scale fire events to provide information to the relevant agencies and the public.

Parameter 9--Total Water Content (DoD). (USAF) Liquid water information is required at the given values to identify, analyze, and forecast conditions favorable for air frame icing and contrail formation, forecast precipitation amounts, and as input to Tactical Decision Aids. Threshold values are documented in AWS Report.

Cloud Parameters (Para 4.1.6.3.)

Parameter 1--Cloud Base Height (DOC/DoD). (USAF) Ceiling height data at the specified threshold values are vital to determining areas of potential icing and determining the most effective weapon delivery altitudes. Threshold values are established in AWS Report. AFWA is capable of determining bases and tops of four cloud layers at 6 km resolution using DMSP visible and thermal fine data, but more rigorous accuracy demanded of NPOESS requires microwave data and limits the achievable cell size to 25 km and refresh to 6 hours.

(DOC) This EDR is derived from imagery and atmospheric sounding data. DOC threshold requirements are consistent with values specified in parameters for Atmospheric Vertical Moisture Profile, Atmospheric Vertical Temperature Profile, and Imagery.

Parameter 2--Cloud Cover/Layers (DoD/DOC). (USAF) Cloud cover data at the specified values is a critical input to general forecasting, albedo measurements, E-O weapons utility forecasting, and other meteorological applications. Threshold requirements are established in AWS Report. AFWA is capable of determining bases and tops of four cloud layers at 6 km resolution using DMSP visible and thermal fine data, but more rigorous accuracy demanded of NPOESS requires microwave data and limits the achievable cell size to 25 km and refresh to 6 hours.

(DOC) This EDR is derived from imagery and/or atmospheric sounding data. DOC threshold requirements are consistent with values specified in parameters Atmospheric Vertical Moisture Profile, Atmospheric Vertical Temperature Profile, and Imagery.

Parameter 3--Cloud Particle Size Distribution (DOC/DoD). (DOC) Aerosols play a major role in forcing climate change via both cooling and warming; presently they pose the largest uncertainty in the Intergovernmental Panel for Climate Change (IPCC) assessments of global change. Requirements are the result of consensus among NOAA, NASA, and other experts, and are consistent with findings and recommendations of the IPCC and several academy reports.

Parameter 4--Cloud Effective Particle Size (DOC/DoD). (USAF) These data are required in global numerical weather prediction (NWP) models and in hurricane forecasting at threshold values established in AWS Report. AFWA is capable of determining bases and tops of four cloud layers at 6 km resolution using DMSP visible and thermal fine data, but more rigorous accuracy demanded of NPOESS requires microwave data and limits the achievable cell size to 25 km and refresh to 6 hours.

(USN) Navy Requirements Review concluded skill in forecasting aircraft icing depends, in part, on predicting cloud effective particle size. At a horizontal resolution of 50 km, vertical reporting interval of 1 km, measurement range of 0-50 μm, and refresh of 6 hours, this parameter, in conjunction with other cloud data parameters, will aid the forecaster in judging the collection efficiency of the aircraft surfaces to supercooled water droplets in both stratiform and cumuliform clouds. It will also aid in the forecast of rime versus clear icing. It is an important element of the enroute data segment of the flight weather briefing package as outlined in NAVOCEANCOMINST 3140.14C.

(DOC) This EDR is derived from imagery, atmospheric sounding data, and/or microwave observations. NOAA threshold requirements are consistent with and justified by values specified under the Atmospheric Vertical Moisture Profile, Atmospheric Vertical Temperature Profile, Imagery, Sea Surface Winds, and Soil Moisture parameters.

Parameter 5--Cloud Ice Water Path (DOC). (DOC) This EDR is derived from imagery, atmospheric sounding data, and microwave observations. DOC threshold requirements are consistent with values specified in parameters for Atmospheric Vertical Moisture Profile, Atmospheric Vertical Temperature Profile, Imagery, Sea Surface Winds, and Soil Moisture.

Parameter 6--Cloud Liquid Water (DOC/DoD). (USAF) With appropriate assumptions, this parameter may be related to cloud optical thickness which is key to determining EO weapon effectiveness. Threshold values are established in AWS Report. AFWA is capable of determining bases and tops of four cloud layers at 6 km resolution using DMSP visible and thermal fine data, but more rigorous accuracy demanded of NPOESS requires microwave data and limits the achievable cell size to 25 km and refresh to 6 hours.

(DOC) This EDR is derived from imagery, atmospheric sounding data, and microwave observations. DOC threshold requirements are consistent with values specified in parameters for Atmospheric Vertical Moisture Profile, Atmospheric Vertical Temperature Profile, Imagery, Sea Surface Winds, and Soil Moisture.

Parameter 7--Cloud Optical Thickness (DOC). (DOC) This EDR is derived from imagery, atmospheric sounding data, and microwave observations. DOC threshold requirements are consistent with values specified in parameters for Atmospheric Vertical Moisture Profile, Atmospheric Vertical Temperature Profile, Imagery, Sea Surface Winds, and Soil Moisture.

Parameter 8--Cloud Top Height (DOC/DoD). (USAF) Used in severe weather forecasting and aircraft routing. Threshold values are established in AWS Report. AFWA is capable of determining bases and tops of four cloud layers at 6 km resolution using DMSP visible and thermal fine data, but more rigorous accuracy demanded of NPOESS requires microwave data and limits the achievable cell size to 25 km and refresh to 6 hours.

(USN) Navy Requirements Review concluded skill in forecasting aircraft icing depends, in part, on predicting the thickness of the layer in which icing conditions occur. The cloud top height parameter gives an upper bound for the layer in which icing can occur. At a horizontal resolution of 25 km, a measurement accuracy from 0.5 km to 2 km, and a refresh of 6 hours, this parameter, in conjunction with the other cloud data parameters, will help the forecaster predict rime and mixed icing in stratiform clouds from 3000-6000 feet; and clear or mixed icing in cumuliform clouds from 3000-20000 feet. It is an important element of the enroute data segment of the flight weather briefing package as outlined in NAVOCEANCOMINST 3140.14C.

(DOC) This EDR is derived from imagery, atmospheric sounding data, and/or microwave observations. NOAA threshold requirements are consistent with and justified by values specified under parameters for Atmospheric Vertical Moisture Profile, Atmospheric Vertical Temperature Profile, Imagery, Sea Surface Winds, and Soil Moisture.

Parameter 9--Cloud Top Pressure (DOC). (DOC) This EDR is derived from imagery and/or atmospheric sounding data. DOC threshold requirements are consistent with values specified in parameters for Atmospheric Vertical Moisture Profile, Atmospheric Vertical Temperature Profile, and Imagery.

Parameter 10--Cloud Top Temperature (DOC/DoD). (USAF) This data is used in operational forecasting. Threshold values are established in AWS Report. AFWA is capable of determining bases and tops of four cloud layers at 6 km resolution using DMSP visible and thermal fine data, but more rigorous accuracy demanded of NPOESS requires microwave data and limits the achievable cell size to 25 km and refresh to 6 hours.

(DOC) This EDR is derived from imagery and/or atmospheric sounding data. DOC threshold requirements are consistent with values specified in parameters for Atmospheric Vertical Moisture Profile, Atmospheric Vertical Temperature Profile, and Imagery.

Earth Radiation Budget Parameters (Para 4.1.6.4.)

Parameter 1--Albedo (Surface) (DOC/DoD). (USAF) Albedo is applied to cloud analyses and used in calculations of inherent contrast between targets and background by E-O weapons systems with values as stated in AWS Report.

(DOC) This EDR is derived from imagery and threshold values are consistent with values specified in the parameter for Imagery.

Parameter 2--Downward Longwave Radiation at the Surface (DOC). (DOC) Stowe, 1988 (Report of the Earth Radiation Budge Requirements Review --1987, NOAA Technical Report NESDIS 41, U.S. Dept. of Commerce, Wash., DC) states a 40 km horizontal spatial resolution is required for input to NWP models, and precision of 0.1 W m^{-2} is required to monitor regional anomalies. Threshold values for measurement accuracy and refresh are the minimums acceptable to demonstrate impact in monitoring studies as cited in Suttles, J. T. and G. Ohring, 1986: Report of the Workshop on Surface Radiation Budget for Climate Applications, Columbia, MD, WCP-115.

Parameter 3--Downward Shortwave Radiation (Surface) (DOC). (DOC) Downward Shortwave Radiation is the primary source of energy to the surface and drives the surface fluxes of water vapor and sensible heat. It is used in soil moisture, snowmelt and crop models. According to the Scientific assessment - National Centers for Environmental Prediction, DOC requires a horizontal spatial resolution of 50 km, a mapping uncertainty of 5 km, measurement accuracy of 20 W m^{-2}, and a daily refresh to run an off-line global soil moisture model that approximates a current state-of-the-art regional model (NCEP Eta model).

Parameter 4--Net Solar Radiation (Top of Atmosphere) (DOC). (DOC) Stowe, 1988: Report of the Earth Radiation Budget Requirements Review - 1987, (NOAA Technical Report NESDIS 41, U.S. Dept. of Commerce, Wash., DC) identifies values consistent with longwave components and specified threshold requirements as key components for monitoring the current state and variability of the climate system.

Parameter 5--Solar Irradiance (DOC). (DOC) The threshold value for measurement range was calculated based on values for spectral irradiance variation cited in White, O., 1977: The Solar Output and its Variation, Table 2, pp. 185-186. Precision, measurement accuracy and refresh threshold requirements are based on variations of solar irradiance over the solar cycle and its impact on global climate change as documented by National Research Council, 1994: Solar Influences on Global Change.

Parameter 6--Outgoing Longwave Radiation (Top of Atmosphere) (DOC). (DOC) Stowe, 1988: Report of the Earth Radiation Budget Requirements Review - 1987, (NOAA Technical Report NESDIS 41, U.S. Dept. of Commerce, Wash., DC) identifies values consistent with specified threshold requirements as key components for monitoring the current state and variability of the climate system. The wavelength interval for the downward longwave and downward shortwave radiation should be consistent with that for the outgoing longwave and shortwave radiation to space.

Land Parameters (Para 4.1.6.5.)

Parameter 1--Land Surface Temperature (DoD/DOC). (USAF) The requirement for land surface temperature at specified threshold values is established in the Concept Paper for US Army Tactical Weather and Environmental Data Requirements (Oct 91) and AWS Report.

(DOC) This EDR is derived from imagery and/or atmospheric sounding data. DOC threshold requirements are consistent with values specified in parameters Atmospheric Vertical Moisture Profile, Atmospheric Vertical Temperature Profile, and Imagery.

Parameter 2--Vegetation Index (DOC/DoD). (DOC/DoD) This EDR is derived from imagery and threshold values are consistent with values specified in the parameter for Imagery.

Parameter 3--Snow Cover/Depth (DoD/DOC). (USAF) Snow cover data at specified values are required to determine background conditions for electro-optical weapons systems and forecasts of trafficability. Threshold values are established in AWS Report.

(USA) IAW Army FM 34-81-1, snow cover data are required to determine background conditions for E-O weapons systems. Forecasts of soil trafficability, river stage, flood, air rescue conditions, and other phenomena also depend on this information, especially for data-sparse and data-denied areas.

(DOC) This EDR is derived from imagery, atmospheric sounding data, and microwave observations. DOC threshold requirements are consistent with values specified in parameters for Atmospheric Vertical Moisture Profile, Atmospheric Vertical Temperature Profile, Imagery, Sea Surface Winds, and Soil Moisture.

Parameter 4-- Surface Type (DoD). (USAF) The parameter is required as input to the agricultural analysis model supporting various U.S. Government customers and to EOTDA forecast models used by all services at threshold values documented in AWS Report.

Ocean/Water Parameters (Para 4.1.6.6.)

Parameter 1--Surface Currents (DOC). Deleted.

Parameter 2--Sea Surface Temperature (SST) Gradients (DOC) (DoD). Deleted.

Parameter 3--Net Heat Flux (DoD). (USN) Navy Requirements Review concluded knowledge of net heat flux is essential to the correct physical modeling of natural phenomena occurring at the air/sea interface for both numerical meteorological and oceanographic prediction models. Horizontal resolutions of 20 km with a measurement range of 0-2000 W m^{-2}, measurement accuracy of 10 W $m^{-2}$and a refresh of 6 hours specify the requirements needed for direct assimilation into global models to yield prognostic charts used to forecast mesoscale features in support of naval operations worldwide.

Parameter 4--Sea Ice Characterization (DOC/DoD). (USN) Sea ice must be monitored globally on a daily basis to permit ice edge delineation to protect mariners, support military operations and provide climatological information. Use of all-weather imagery allows both ice analysts and automated ice algorithms to determine ice location to a gross scale whether conditions are cloudy or clear, thereby supporting a hemispheric daily product. While this product is not satisfactory for precise operations, it is useful for ice forecast models. This product also serves to identify areas of new ice, which due to its thin nature, often defies being observed using either visible or infrared imagery.

Parameter 5--Ice Surface Temperature (DOC/DoD). (DOC/USN) Currently, sea ice (and freshwater ice) thickness-and hence, tensile strength, is estimated using frost degree data compilations from shore station temperature reports in middle and high latitudes. Surface temperatures are not available in data sparse regions throughout the Arctic and Antarctic, making ice thickness estimations difficult and, potentially, inaccurate. Remotely-sensed ice surface temperatures would be an invaluable daily, large scale, and reliable data set used to estimate sea ice growth and decay. The temperature sensor shall be accurate to within 1 degree Celsius to ensure an accurate calculation of frost degree day information.

Parameter 6--Ocean Color (DoD/DOC). (USN) Navy Requirements Review concluded ocean color from a polar-orbiting weather satellite is needed to identify bioluminescence potential and locate such water-mass features as fronts and eddies for antisubmarine warfare operations, and observe changing optical conditions (turbidity) in coastal regions to predict electro-optical system performance. Ocean color will be used to complement sea surface temperature analysis where a horizontal resolution/mapping uncertainty of 2 km (global) and 0.25 km (regional) is needed to resolve ocean temperature structures (i.e., eddies and ocean fronts) on the scale of 4 km or less.

(DOC) This EDR is derived from imagery and thresholds for horizontal resolution and mapping uncertainty are consistent with those specified under the Imagery EDR. DOC requires observations to allow quantification of chlorophyll concentrations within a measurement range of 0.05 to 50 mg/m^3 and a measurement accuracy of 30% to support coastal and fisheries management missions, as noted in the following documentation: Hooper, N., and J. Sherman, III, 1986. Temporal and Spatial Analyses of Civil Marine Satellite Requirements, *NOAA Technical Report NESDIS 16*, NOAA/NESDIS; Montgomery, D., R. Patton, S. McCandless, 1984. *Ocean Services User Needs Assessment, Volume 1: Survey Results, Conclusions & Recommendations,* Jet Propulsion Laboratory, Pasadena; and, *NOAA Requirements for Support from Polar-Orbiting Satellites,* NOAA, 1990. The DOC minimum refresh requirement of 24 hours is based upon rate of change in measured phenomena and is minimally acceptable values for oceanic monitoring missions as cited in McClain, E., W. Pichel, A. Strong, and M. Weaks, 1992. *NOAA CoastWatch Ocean Color Prospectus: A Cooperative Approach for Acquisition, Processing, Archiving, and Exchange of U.S. Coastal Ocean Color Data and Data Products,* NOAA/NESDIS.

(DOC/USN Ocean Observer Team) This Ocean Color EDR now includes ocean color (defined as water-leaving radiances), as well as chlorophyll, and ocean optical properties (i.e., absorption and scattering, and chlorophyll flourescence) derived from the water-leaving radiances. The regional resolution specified has been shown to be essential for imaging U. S. Coast Watch regions and similar coastal and continental shelf regions worldwide. These Regions, which possess features with high gradients, demand higher resolution observations than the global resolution. Derived parameters are required at this resolution for coastal dynamics (modeling), human health (red tide, pathogens), oil spill response, and fisheries management. Ocean color measurements and derived EDRs are required at the same resolution as SST Imagery.

(A) Ocean Optical Properties (DoD/DOC); (DOC/USN Ocean Observer Team) Explanation: Ocean optical properties derived from ocean color water-leaving radiances. The surface optical properties of total absorption (a_t) and total backscattering (b_{bt}) at specific wavelengths can be determined from the remote sensing reflectance. Absorption and backscattering can be broken down into additional optical properties. Phytoplankton pigment absorption is used to calculate chlorophyll concentration. Non-phytoplankton absorption (e.g., colored dissolved organic matter, detrital absorption) is required for characterization of river plumes, as a surrogate for salinity, and for understanding of the water quality factors determining light availability (separating phytoplankton from detrital impacts). Backscattering is used to calculate the amount of particulates in the water. The spectral properties of absorption and scattering combined are used to separate phytoplankton, detritus and inorganic particulate matter components in the water.

The surface optical properties of absorption (a; units: m^{-1}), scattering (b, units: m^{-1}), and backscattering (b_b; units: m^{-1}) at specific wavelengths of interest (for example, 412, 443, 490, 520, 532, 555, 580, 600, 665, 680, 720,740, 760, and 870 nm) can be determined from ocean color water-leaving radiances. These inherent optical properties are used to ascertain swimmer visibility and to predict laser performance for underwater imaging and attenuation. They are also employed for detecting and characterizing river plumes, modeling the distribution of pollutants in coastal waters, estimating salinity, calculating phytoplankton primary production, and evaluating seagrass and coral health.

Chlorophyll fluorescence is a measure of the light-harvesting pigments of phytoplankton. The amount of fluorescence is a complicated function of light capture by chlorophyll and the rate of photosynthesis. Much attention has focused on the use of fluorescence to estimate chlorophyll concentrations in the presence of suspended particulate and dissolved material, and to estimate primary productivity. Measurements of chlorophyll fluorescence from space provide 1) an alternative to absorption-based chlorophyll algorithms which may fail in turbid and coastal waters, and 2) an estimate of the photosynthetic "health" of phytoplankton.

Ocean optical properties are needed to predict how equipment systems used by the Navy will perform in the coastal and shelf waters. Real time and historical optical properties are needed for planning the deployment of E-O systems and for logistics during ocean exercises. Navy systems include laser imaging systems and underwater camera systems, as well as diving operations. Underwater detection and targeting systems are influenced by the water absorption of the light (distance from target) and blurring of a target caused by scattering.

(B) Cholorophyll (DoD/DOC); (USN) The optical property most frequently associated with ocean color data is K(490), the diffuse attenuation coefficient at a wavelength of 490 nm (nanometers). Absorption by chlorophyll and other plant pigments is a major component of K(490), and variability in pigment concentration dominates variability in K(490) horizontally, vertically, and over time. Navy Requirements Review concluded a measurement range of chlorophyll concentration of 0.5-50 g m^{-3} (cubic meter) is required to calculate the extinction of solar radiation with depth as a function of chlorophyll concentration. This allows water-mass differentiation as an operational tool. The measurement accuracy of +/-30% is based on the analysis of historical ocean color data bases using the Coastal Zone Color Scanner (CZCS).

(DOC/USN Ocean Observer Team) Chlorophyll *a* represents the primary plant pigment used to absorb light and represents the commonly accepted estimate of phytoplankton biomass in biological investigations.

Chlorophyll is required for determination of primary production and phytoplankton abundance. Chlorophyll measurements in highly eutrophic coastal waters require the proposed new level of precision to accommodate modeling requirements. Satellite ocean color sensors and processing algorithms should ideally be capable of estimating chlorophyll a concentration over the range 0.01 to 50 mg/ m^3. This range would encompass highly eutrophic conditions and events like algal blooms, as well as the clearest oceanic waters found in extremely oligotrophic areas. Recent data from the SeaWiFS ocean color sensor reveal a mean global deep-water chlorophyll a concentration of approximately 0.22 mg m^{-3} with a substantial portion of the global ocean with concentrations below 0.03 mg m^{-3}. These clearest waters and highly eutrophic areas represent bio-optical and ecological extremes and changes in their magnitude or areal distribution may provide very sensitive indicators of global change.

<u>Parameter 7--Sea Surface Height (DOC)/Topography (DoD)</u>. (USAF) Tide and current data are required by Army Special Operations Forces at the specified threshold values as documented in AWS Report.

(A) <u>Mesoscale Ocean</u>; (DOC) Mesoscale sea surface height is associated with eddies and western boundary currents having length scales up to a few hundred km and time scales of days to weeks. Examples off the US coast are the Gulf Stream, the Loop Current in the Gulf of Mexico, rings/eddies formed by these currents, and eddies of the California Current system. NOAA programs such as NCEP's Coastal Ocean Forecast System presently assimilate a variety of ocean data, including sea surface height from satellites. The National Hurricane Center also takes advantage of sea surface height data to help in the estimation and forecast of hurricane intensity. For applications such as these, timeliness is critical, with observations required with no more than a 24-hour delay. Absolute accuracy of the sea surface height measurement (i.e., radial orbit determination) is less important because the data can be high-pass filtered to reveal the mesoscale features of interest. This requirement, derived from NOAA's goal of advancing short-term warning and forecasts services, is described in the publications: "National Ocean Partnership project advances real-time coastal ocean forecasting", *EOS Trans. AGU,* 81 (14), 145-150, 2000, and "Controls on hurricane intensity", *Nature,* 40, 665-669, 1999, and Modern Approaches to Data Assimilation in Ocean Modeling, Elsevier Oceanography Series, 61, 347-376, 1996.

(DOD) Mesoscale sea surface height variations associated with eddies and current meanders are the major contributors to ocean temperature changes. The thermocline shifts correlated to the surface pressure changes dramatically alter the ocean environment within which the Navy must operate. In addition, the mesoscale field is a large contributor to the ocean currents. Because the mesoscale field is chaotic, not directly related to the wind field, and thus not predictable far in advance, continuous observations of the mesoscale field are required to monitor the environment that may impact Navy acoustic operations for Anti Submarine Warfare (ASW) and prediction of mine drift trajectories. Operational systems are presently in place within the Naval Oceanographic Office to exploit available altimeter data streams. The operational systems provide daily observations to numerical model systems that in turn feed information to the Navy fleet. Timeliness is essential for these operational products. In line with the DOC requirements, radial orbit accuracy is of secondary concern for the mesoscale products. The majority of the orbit solution errors are removed through post processing at the Navy operational centers. The Navy mesoscale requirements are outlined in the document “Navy Altimeter Data Requirements”, Naval Research Laboratory, *NRL/FR/7320—99-9696*, November, 1999.

(B) Basin Scale Ocean; (DOC) Basin scale sea surface height is associated with large-scale ocean circulation having length scales of a few thousand km and time scales of weeks to months. An example is the El Nino Southern Oscillation which affects seasonal rainfall and temperatures in the U.S. Sea surface height variations observed by satellites are presently assimilated by NOAA/NCEP into ocean models which form the basis for long-range forecasts of weather and climate. These forecasts are updated weekly, so delays in data delivery of 2-3 days can be tolerated. Absolute accuracy is of paramount importance, however, as changes in sea surface height of <5 cm can be indications of significant changes in subsurface temperature and salinity. Other basin scale variations of interest include the Pacific Decadal Oscillation, the North Atlantic Oscillation, and baroclinic Rossby waves, all of which are related to inter-annual and inter-decadal patterns of climate change. This requirement, derived from NOAA’s goal of implementing seasonal to inter-annual climate forecasts, is described in the publication: “Use of Topex/Poseidon sea level data for ocean analyses and ENSO prediction: Some early results”. *J. Climate*, 13, 216-231, 2000.

(DOD) For Navy applications, the basin scale ocean circulation influences the ocean environment through two processes. First, large-scale events such as El Nino significantly alter the background ocean temperature field. These shifts from climatology shall be accounted for in environmental prediction systems. Second, the major ocean circulation gyres provide the energy upon which the mesoscale field feeds. For the mesoscale field to develop properly within ocean circulation models, the energy must be transferred from the large-scale circulation to the mesoscale. Correctly constraining the basin scale ocean circulation is a requirement to accurate prediction of the whole ocean environment for the Navy.

(C) Global Scale Ocean; (DOC) Global scale sea surface height variability has planetary length scales and time scales of years to decades. Studies analyzing tide gauge data indicate that the 20th century sea level rise is 1-2 mm per year, but it is not known whether this rise is accelerating in response to global warming. Such a determination can be obtained only from satellites, which afford complete sampling of the global oceans. Because of the obvious consequences of global sea level rise, measurement of this parameter is considered by NOAA to be an operational responsibility. Timeliness is of little importance, but monitoring global sea level with an accuracy of 1 mm per year will require the highest levels of accuracy, including long-term calibration. This requirement, derived from NOAA’s goal of predicting and assessing decadal to centennial change, is described in the 1997 Workshop Report: “Climate Measurements Requirements for NPOESS.” For a current assessment of altimeter accuracy, see “Satellite altimetry” in: Satellite Altimetry and Earth Sciences: A Handbook for Techniques and Applications 1-131, Academic Press, San Diego, 423 pp, 2000. Also see "Variations in global mean sea level associated with the 1997-1998 ENSO event: Implications for measuring long term sea level change”, Geophys. Res. Lett., 26(19), 3005-3008, 1999.

Parameter 8--Ocean Wave Characteristics – Significant Wave Height (DoD/DOC). (USAF) Sea state condition data at the required values are required by Army Engineers as it affects site selection and the operations of port and beach facilities. Threshold values are established in AWS Report.

(USN) Navy Requirements Review concluded the parameters of Sea Surface Winds, Sea Height/Topography and Ocean Currents have a direct effect on ocean wave characteristics. This is reflected in the global (20 km) and regional horizontal resolution (0.5 km), and global (5 km) and regional mapping uncertainty (0.5 km). The measurement accuracy (height +/- 0.3 m, direction: +/- 10%) is attributed to sea surface wind errors (+/-10%) that induce similar ocean wave height errors. Thus, a +/- 10% error in ocean wave height with a measurement range of 0.5-30 m will roughly yield a measurement accuracy of +/-0.3 m.

(USA) IAW FM 34-81-1, sea state condition knowledge is required by Army engineers as it affects site selection and the operations of port and beach facilities.

(DOC) Thresholds are consistent with DOC requirements for future forecast model improvements resulting from direct assimilation of wave measurements, described in NOAA Polar-Orbiting Satellite Requirements Study, DOC, 1990; and in Ocean-Atmosphere Observations Supporting Short-Term Climate Predictions, National Academy Press, 1994.

The measurement of significant wave height from space has been adequately demonstrated by a number of satellites.

Waveform Data is required to produce a Significant Wave Height EDR. In order for this EDR to be received at the Tactical IDP, waveform data must either be used on board the satellite to calculate an EDR and transmit via HRD or waveform data must be transmitted for calculation of the EDR by the Tactical IDP.

Parameter 9--Global Sea Surface Wind Stress (DOC/DoD). Sea Surface Wind Stress is a parameter derived from Sea Surface Wind Speed and Direction as well as air-sea temperature difference.

(USN) Navy Requirements Review concluded surface wind stress from a polar-orbiting satellite is needed to construct quality analyses of ocean currents. Skill in surface sea surface wind stress analysis depends heavily on the skill of predicting sea surface winds. Navy Requirements Review concluded the finer the resolution, or cell size, the closer one can come to the littoral region for special studies of upwelling and other near-shore ocean events and the less data are lost. For this reason, the horizontal resolution is 20 km and mapping uncertainty 7 km that falls within the grid resolution for planned global and regional meteorological/oceanographic models (i.e., 50 km).

(DOC) DOC regards this EDR as a derived parameter, resulting from sea surface wind measurements of the relative thresholds detailed in the Sea Surface Wind Speed EDR.

Space Environmental Parameters (Para 4.1.6.7.)

Parameter 1--Auroral Boundary (DoD/DOC), Parameter 2--Auroral Energy Deposition (DoD/DOC), Parameter 3--Auroral Imagery (DoD/DOC), Parameter 4--Electric Field (DoD/DOC), Parameter 5--Electron Density Profile (DoD/DOC), Parameter 6--Geomagnetic Field (DoD/DOC), Parameter 7--In-situ Plasma Fluctuations (DoD/DOC), Parameter 8--In-situ Plasma Temperature (DoD/DOC), Parameter 9--Ionospheric Scintillation (DoD/DOC), Parameter 10--Neutral Density Profile (DoD/DOC), Parameter 11--Medium Energy Charged Particles (DoD/DOC), Parameter 12--Energetic Ions (DoD/DOC), Parameter 13--Supra-thermal through auroral energy particles (DoD/DOC). The Space Environmental Parameters have threshold values established in a joint DOC/DoD study, "Space Environmental Monitoring Requirements For Polar Orbiting Spacecraft." These parameters shall be measured continuously in each orbital plane, at specified resolutions, to get a representative sampling of the ionosphere, which is itself semi-sun-synchronous. In addition, equal spacing, and adequate coverage of the dawn/dusk transitions and the approximate noon/midnight fluctuations are necessary. One exception to these requirements is the solar EUV flux, which is obtained by viewing the sun directly.

Potential Pre-Planned Product/Process Improvements (P^3I) Section (4.1.6.8)

Parameter 1--Tropospheric Winds (DOC/DoD). Global Tropospheric wind measurements are needed for numerical weather, climate, and military operations. Accurate and timely knowledge of the direction and speed of global troposheric winds would significantly improve the understanding and predicton of weather and climate. Currently, tropospheric wind data is derived from indirect measurements from satellite-retrieved temperature measurements. Benefits from improved prediction of climate due to accurate global wind data include economic benefit from either unwarranted action or inaction in response to the uncertain prospect of global climate change, improved hurricane forecasts and general forecasting abilities, and better fuel consumption planning by commercial airlines.

A wind profile is required for cloud returns and planetary boundary layer aerosol returns.

The information derived from this product supports aviation flight planning and the prediction of dispersal of atmospheric pollutants.

Parameter 2--CH_4 (Methane) Column (DOC). The presence of trace gases in the atmosphere can have a significant effect on global change. The chemical composition of the troposphere in particular is changing at an unprecedented rate. The rate at which pollutants from human activities are input to the troposphere is now thought to exceed that from natural sources (e.g., volcanic eruptions) and is known to be greater than the atmosphere's natural capacity for their removal.

This data product allows monitoring changes in the composition of the various layers in the atmosphere and to deduce the effects of these changes on the global climate. High speed spectral resolution is needed to detect the absorption, emission, or scatter for individual species (trace gases).

This data is used to understand sources and sinks of trace gases. In atmospheric chemistry, there is strong evidence of increasing concentrations of cfcs, carbon dioxide, methane, etc. Realistic scenarios for future atmospheric concentrations, especially for methane, are difficult to deduce because of an inadequate understanding of the sources and sinks of these substances. Major uncertainties in the future evolution of the ozone layer arise from the uncertain future concentrations of the distribution of several stratospheric constituents, such as water vapor.

The presence of trace gases in the atmosphere can have a significant effect on the potentially harmful local effects through increased levels of pollution.

Parameter 3--CO (Carbon Monoxide) Column (DOC). The presence of trace gases in the atmosphere can have a significant effect on global change. The chemical composition of the troposphere in particular is changing at an unprecedented rate. The rate at which pollutants from human activities are input to the troposphere is now thought to exceed that from natural sources (e.g., volcanic eruptions) and is known to be greater than the atmosphere's natural capacity for their removal.

This EDR supports monitoring of changes in the composition of the various layers in the atmosphere and analyses of the effects of these changes on the global climate. High spectral resolution is needed to detect the absorption, emission, and scattering for individual species (trace gases).

The presence of trace gases in the atmosphere can have a significant effect on potentially harmful local effects through increased levels of pollution.

Parameter 4--CO_2 (Carbon Dioxide) Column (DOC). This EDR is a measure of the carbon dioxide contained in a specified volume of air. This EDR supports monitoring of sources and sinks of CO_2. CO_2 is a chemically stable gas that has an important effect on climate. The present ground-based network is probably adequate for monitoring its steady increase, which is in part because of the burning of fossil fuels, and secondarily to deforestation. For studying sources and sinks, however, it is necessary to monitor the geographical and seasonal variations which would required a spaceborne monitoring system.

The presence of trace gases in the atmosphere can have a significant effect on global change. The chemical composition of the troposphere in particular is changing at an unprecedented rate. The rate at which pollutants from human activities are input to the troposphere is now thought to exceed that from natural sources (e.g., volcanic eruptions) and is known to be greater than the atmosphere's natural capacity for their removal.

This EDR is used to monitor changes in the composition of the various layers in the atmosphere and to deduce the effects of these changes on the global climate. High spectral resolution is needed to detect the absorption, emission, and scattering for individual species (trace gases).

Parameter 5--Optical Backgrounds (DoD). This EDR measures emissions that are the result of interactions between precipitating energetic particles and solar ultraviolet radiation with neutral atmospheric constituents. Optical background data is used to set thresholds for threat detection systems supporting missile and space defense assets.

Parameter 6--All Weather Day/Night Imagery (DoD/DOC). Included are imagery requirements for high-resolution all-weather backscatter imagery. For high resolution (all weather imagery), image pixel spacing should be ½ the spatial resolution give. Coverage of high resolution all-weather imagery includes: (1) regional scale areas which may be fairly large (but not global) and include all of the waters adjacent to the U.S. and all-ice covered ocean areas worldwide as well as the Great Lakes when ice covered, (2) littoral scale areas that include targeted areas (such as coastal areas) requiring higher-resolution coverage (e.g., a sea lion rookery area and protected waters), and (3) local scale areas that are typically focused targets that require coverage at the highest resolution (e.g., a barrier island modified by a hurricane). Local scale oil spill models and detection of volcanic bulging require local scale coverage at 5 m resolution. Refresh means possible refresh for a given target, not refresh for all possible locations (i.e., high resolution coverage of only a portion of the possible coverage area).

(DOC/DoD) This is a new EDR for high resolution all-weather land and sea surface imagery. Pixel spacing should be ½ the spatial resolution. Coverage of high resolution all-weather imagery includes: (1) regional scale areas which may be fairly large, perhaps up to one third of an orbit (but not global) and include all of the waters adjacent to the U.S. and all-ice covered ocean areas worldwide as well as the Great Lakes when ice covered, and selected regions worldwide, (2) littoral scale areas that include targeted coastal areas requiring higher-resolution coverage (e.g., a sea lion rookery area and protected waters), and (3) local scale areas that are typically focused targets that require coverage at the highest resolution (e.g., a barrier island modified by a hurricane). High resolution all-weather imagery is required by the National Ice Center and NWS Alaska Region and useful to other users such as the U.S. Coast Guard and the Alaska Dept. of Fish and Game. This requirement is based on experience with all-weather high resolution imagery which are essential for analysis of ice patterns of concentration, type, age, motion, and edge location as well as other derived parameters (see List 3). Regional-scale coverage is required for wind determination, vessel detection, oil spill mapping, and for land areas for flood mapping. Coverage of coastal areas and selected land areas at coastal resolution is required for coastal oil spill and hazardous algal bloom mapping, flood mapping, and river ice breakup monitoring. Coverage of selected limited areas at local scale is required for shoreline mapping in chronically cloud-covered areas.

<u>List 3</u>
Environmental Measurements Derived from High-Resolution All-Weather Imagery

<u>Atmospheric Parameters</u>	<u>Ocean Parameters</u>
Mesoscale and Microscale Atmospheric Features with surface expression	Regional Sea Surface Winds
	Regional Sea Surface Wind Stress
<u>Land Parameters</u>	Ocean Wave Characteristics – Wave Direction/Wavelength
Flood Mapping	Oil Spill Location
River Ice Location/Condition	Ice of Land Origin (Icebergs)
	Bathymetry
	Sea and Lake Ice Concentration/Age/Motion/Edge Location
	Surf Conditions

<u>Parameter 7--Sea and Lake Ice Concentration/Age/Motion/Edge Location (DOC/DoD)</u>. (DOC) Justification for thresholds presume this parameter is derived from high-resolution, all weather Imagery. Requirements are based on: a) mission; b) current state and expected evolution of relevant science disciplines and remote sensing technologies; c) planned or expected changes in organizations, mission emphasis or resources; and d) needs of non-NOAA clientele. These requirements are documented in "NOAA Requirements for Support from Polar-Orbiting Satellites," 1990, and previously in "Envirosat 2000 Report, NOAA Satellite Requirements Forecast", May 1985. This document shows a requirement for at least 0.4 km horizontal resolution for ice coverage at nadir. Since 1996, this EDR has been partially fulfilled by Canadian RADARSAT-1 imagery, providing 0.1 km horizontal cell size imagery for areas around Alaska and within the Great Lakes. Besides providing smaller spatial resolution, radar imagery also provides the ability to collect imagery through all-weather and regardless of day-night conditions, both of which are issues in polar regions. In areas where RADARSAT imagery is unavailable, imagery from other sensors are called upon to provide information.

(DOC/USN) The recent creation of the Environmental Working Group (EWG) Sea Ice Atlas, which compiled 19 years of sea-ice concentration and extent, forms a short-term climatological signal to monitor Global Warming. Use of all available sensors to continue monitoring polar ice conditions which is a key indicator, and potential driver, of global climate change is essential.

(USN). Arctic naval operations, in support of national and tactical tasking, are extremely dependent on sea ice age and ice motion as are Antarctic operations. When sea ice obtains a specific age/thickness, icebreaking support is mandatory to prevent vessel damage. "Old" ice achieves significant tensile strength as it becomes compacted over time and salinity is lowered. Similarly, submarine surfacing operations are highly dependent on sea ice concentration and ice cover thickness. Further, ridging of "old" ice can result in ice keels penetrating to tens of meters below the sea surface, and pose a significant hazard to submarine navigation. The marginal ice zone (zone of sea ice between open sea and inner ice pack) is subject to significant variability in response to oceanographic and atmospheric forcing. Non-ice strengthened vessels risk damage if sea ice is advected into their operating area due to this forcing. Further, there is significant

National and international interest in the advection of radionuclides from Arctic waters into densely populated coastal regions. Remotely sensed visual and infrared data are critical in assessing this threat. A spatial resolution of at least 100 meters is required to extract sea ice features of sufficient detail to aid in ice analyses and drift estimates.

Parameter 8--Oceanographic Requirements

Parameter 8.1--Littoral Currents (DoD). (USN) As Naval forces continue to focus on Littoral operations, the need to monitor littoral currents increases, especially for Expeditionary Warfare, particularly Mine and Special Warfare. This is especially true in denied areas which require all-weather sensing from satellite altitudes to maintain operational security. Littoral currents must be accounted for in mine placement, lay-over and drift. The damage incurred by two USN ships during the conflict against Iraq, and the loss of the ability of Naval forces to actualize its threat of a whole-scale amphibious landing, were the result of cheap, unsophisticated mines, whose motion could not be effectively tracked due to insufficient Littoral Current information. The ability to insert Naval Special Forces and USMC Recon personnel is also effected by littoral currents. The planning and execution of special operations can be made more effective if the travel time is accurately determined, rather than estimated due to the impact of intervening currents.

Parameter 8.2-- Coastal Ocean Color (DoD/DOC). (USN/DOC) Water-leaving radiances are the quantities measured by an ocean color sensor that are used to derive all of the other ocean color parameters, such as chlorophyll and ocean optical properties. The coastal resolution specified is essential for imaging lakes and rivers, and many typical coastal areas, bays and estuaries that have spatial scales of one to a few kilometers. Lakes, rivers, and coastal regions, which possess features with high gradients, demand high resolution observations. Derived parameters are required at this resolution for coastal dynamics (modeling), human health (drinking water quality, red tide, and pathogens), oil spill response, aquaculture, and fisheries management. Coastal ocean color measurements and derived parameters are required at the same resolution as coastal SST measurements.

Chlorophyll a represents the primary plant pigment used to absorb light and represents the commonly accepted estimate of phytoplankton biomass in biological investigations. Chlorophyll is required for determination of primary production and phytoplankton abundance. Chlorophyll measurements in highly eutrophic coastal waters require the proposed new level of precision to accommodate modeling requirements. Satellite ocean color sensors and processing algorithms should ideally be capable of estimating chlorophyll a concentration over the range 0.01 to 50 mg m^{-3}. This range would encompass highly eutrophic conditions and events like algal blooms, as well as the clearest oceanic waters found in extremely oligotrophic areas. Recent data from the SeaWiFS ocean color sensor reveal a mean global deep-water chlorophyll a concentration of approximately 0.22 mg $m^{-3}$with a substantial portion of the global ocean with concentrations below 0.03 mg m^{-3}. These clearest waters and highly eutrophic areas represent bio-optical and ecological extremes and changes in their magnitude or areal distribution may provide very sensitive indicators of global change.

Ocean optical properties are derived from ocean color water-leaving radiances. The surface optical properties of total absorption (a_t) and total backscattering (b_{bt}) at specific wavelengths can be determined from the remote sensing reflectance. Absorption and backscattering can be broken down into additional optical properties. Phytoplankton pigment absorption is used to calculate chlorophyll concentration. Non-phytoplankton absorption (e.g., colored dissolved organic matter, detrital absorption) is required for characterization of river plumes, as a surrogate for salinity, and for understanding of the water quality factors determining light availability (separating phytoplankton from detrital impacts). Backscattering is used to calculate the amount of particulates in the water. The spectral properties of absorption and scattering combined in the water. The surface optical properties of absorption (a; units: m^{-1}), scattering (b; units: m^{-1}), and backscattering (b_b; units: m^{-1}) at specific wavelengths (λ = 412, 443, 490, 520, 532, 555, 580, 600, 665, 680, 720, 740, 760, and 870 nm) can be determined from ocean color water-leaving radiances. These inherent optical properties are used to ascertain swimmer visibility and to predict laser performance for underwater imaging and attenuation. They are also employed for detecting and characterizing river plumes, modeling the distribution of pollutants in coastal waters, estimating salinity, calculating phytoplankton primary production, and evaluating seagrass and coral health.

Chlorophyll fluorescence is a measure of the light-harvesting pigments of phytoplankton. The amount of fluorescence is a complicated function of light capture by chlorophyll and the rate of photosynthesis. Much attention has focused on the use of fluorescence to estimate concentrations in the presence of suspended particulate and dissolved material, and to estimate primary productivity. Measurements of chlorophyll fluorescence from space provide 1) an alternative to absorption-based chlorophyll algorithms which may fail in turbid and coastal waters, and 2) an estimate of the photosynthetic "health" of phytoplankton.

The fluorescence line height (FLH) algorithm is a relative measure of the amount of radiance leaving the sea surface, which is a result of chlorophyll fluorescence. By constructing a baseline using bands on either side of the fluorescence band, we can estimate the deviation from the amount of radiance expected for pure water that results from chlorophyll fluorescence. This increase in radiance (centered at 683 nm for chlorophyll) has been noted for decades in measurements of the light field in the ocean. This signal is generally weak, even in regions of high chlorophyll concentrations. To measure fluorescence, the signal to noise ratio (SNR) must be increased for the fluorescence band in the adjacent "baseline" bands at 665 nm and 750 nm. Typical SNR for these three bands must be in the range of 1200-1500 to make usable measurements of fluorescence in waters with chlorophyll levels as low as 0.5 mg m^{-3}. For lower chlorophyll waters, pixels must be averaged together in order to increase the effective SNR. The fluorescence measurement itself is made at 678 nm as a compromise between measuring the fluorescence peak (683 nm) and the presence of an oxygen absorption band at 687 nm.

Ocean optical properties are needed to predict how equipment systems used by the Navy will perform in the coastal and shelf waters. Real time and historical optical properties are needed for planning the deployment of E-O systems and for logistics during ocean exercises. Navy systems include laser imaging systems and underwater camera systems, as well as diving operations. Underwater detection and targeting systems are influenced by the water absorption of the light (distance from target) and blurring of a target caused by scattering.

Parameter 8.3-- Bioluminescence Potential (DoD). (USN) Bioluminescence Potential represents the probability of eliciting a detectable flash of light by disturbing light-producing organisms within the ocean. High levels of bioluminescence can indicate the presence of boats, swimmers or other objects moving through the water, thereby threatening the success of the operations. This potential results from a complex interplay between the abundance and taxonomic composition of organisms in the surface layer, ambient light level, sea surface temperature, and other factors. To meet this requirement, bioluminescence potential may be stated in broad categories (e.g. high, medium or low), hence no specific measurement accuracy is given.

Parameter 8.4--Coastal Sea Surface Temperature (SST) (DOC/DoD). (USN/(DOC) These are high-resolution measurements of SST in limited regions. SST measurements in bays, rivers, estuaries, lakes, and near-shore regions when paired with coastal ocean color, chlorophyll, and optical properties allow analysis of the dynamics of coastal areas, for water quality monitoring, oil spill response, support to aquaculture, and fisheries management.

High resolution sea surface temperatures are needed as input to Navy ocean circulation models that support operational exercise activities in littoral regions. Real time temperature and ocean circulation data are needed for planning the deployment of personnel and mission assets in specified regions that are often 1-2 km in scale and characterized by changing ocean coastal dynamics. Navy activities supported by this high resolution data include swimmer delivery vehicle operations, autonomous underwater vehicle operations, and SEAL team operations.

Parameter 8.5--Coastal Sea Surface Winds (Speed and Direction) and Wind Stress (DOC). (DOC/USN Ocean Observer Team) High-resolution all-weather winds are required regionally (predominantly in coastal areas). These winds shall be available up to the coast and in bays and estuaries. Coverage of the U.S. coasts, particularly coastal Alaska and selected off-shore regions (such as the Bering Sea) is required. Coverage is also required in selected areas worldwide to respond to tactical requirements in the littoral zone. It is not anticipated that the volume of coverage at regional resolution will require coverage during more than 30 minutes each orbit (i.e., less than one third of each orbit); however, coverage of multiple regions globally within the coverage region of each orbit will be normally required.

The regional wind requirement is from the NWS Alaska Region. Recent experience with an experimental coastal wind product in Alaska waters (verified by ship observations) shows that there are 50 knot wind gradients over spatial scales of 5-10 km in critical coastal areas like Shelikof Strait and along the coastal mountain barrier in the northeast Gulf of Alaska. Measurements shall be made up to the coast, around islands, and in bays and estuaries to capture the gradients that exist. High resolution winds are also needed in areas of low pressure systems to accurately forecast height and direction of high surf events. Many significant weather episodes are produced by small perturbations in normal conditions. These shall be detected in order to forecast their impact. This also applies to military operations. USN/USMC operations in the littoral, particularly expeditionary amphibious assault, are severely affected by local high winds and the surf/seas generated.

Another user of regional mesoscale winds is the mesoscale modeling community. In recent years, the horizontal resolution of regional mesoscale numerical weather prediction models has increased to operational grids of 12 km with nested grids of 4 km. At these resolutions, it is possible to resolve the terrain-forced flows responsible for the large wind gradients mentioned above. In addition to such products as the coastal wind product mentioned above, regional, high resolution coastal winds are critical for the verification of data for the initialization and data assimilation process.

(USN) Sea surface wind stress is a derived parameter from sea surface wind speed and direction as well as air-sea temperature difference. Navy requirements review concluded surface wind stress from polar-orbiting satellite is needed to construct quality analyses of ocean currents. Skill in sea surface wind stress analysis depends heavily on the skill of predicting sea surface winds. The more fine the resolution, or cell size, the closer one can come to the littoral region for special studies of upwelling and other near-shore ocean events and the less data are lost.

(DOC) Sea surface wind stress is a derived parameter, resulting from sea surface wind measurements of the relative thresholds detailed in the coastal sea surface winds speed and direction product requirements.

Parameter 8.6--Sea Surface Height Coastal (DoD). (USN) Coastal sea level variability is required for estimation of tidal sea level variations and tidal current variations. Coastal sea surface height differs from that currently used for open ocean measurements by the distance from shore measurement. The sea level data is needed as close to shore as possible to provide data in coastal areas that contain features with small spatial scales. The sea surface height data is used to provide estimates of both tidal constituent amplitudes and phases and the effect of wind-driven seiches. Accurate knowledge of these factors influences the effect of sea level, therefore the width and slope of beaches. This is critical for all amphibious operations.
Operational products in the near future are expected to use the sea level variations across critical straits such as the Taiwan Strait or Korea Strait between Korea and Japan. These straits are critical choke points for controlling the circulation and ocean environment throughout the east Asian Marginal Seas region. Sea surface height information across these straits will be used to constrain numerical models.

(DOC) Coastal sea level variability is required for estimation of both tidal and subtidal sea level and current variations. The sea level observations are needed as close to shore as possible to provide data in coastal areas near the entrances to estuaries and harbors where features with small spatial scales are found. These data can be used to provide estimates of tidal constituent amplitudes and phases which can then be analyzed in inverse solutions to provide sea level and current variations associated with the tides. This information can be compared with the same tidal estimates obtained from coastal water level observations from National Ocean Service (NOS) gauges. Operational products are expected to use the altimeter-derived sea level variations as open ocean boundary conditions for NOS estuarine nowcast and forecast model-based systems. Lake surface heights and other measurements are required in fine spatial scales (several km) and temporal resolution (< 1 day). Operational services such as the forecasting system at NOAA's Great Lakes Environmental Research Laboratory and Ohio State University require lake elevation changes as input to their operational modeling effort ("The Great Lakes Forecasting System" Coastal Ocean Prediction, CRC Press, 1996.).

Parameter 8.7--Coastal Imagery (DoD)

Parameter 8.8--Ocean Wave Characteristics-Ocean Wave Direction/Wavelength (DoD/DOC). (DOC/USN Ocean Observer Requirements Team) These parameters were separated from the Significant Wave Height EDR as they cannot be readily measured with current technology, but remain a requirement for both DOC and DoD.

(USAF) Sea state condition data at the required values are required by Army Engineers as it affects site selection and the operations of port and beach facilities. Threshold values are established in AWS Report.

(USN) Navy Requirements Review concluded the parameters of Sea Surface Winds, Sea Height/Topography and Ocean Currents have a direct effect on ocean wave characteristics. This is reflected in the global (20 km) and regional horizontal resolution (0.5 km), and global (5 km) and regional mapping uncertainty (0.5 km). The measurement accuracy (height +/- 0.3 m, direction: +/- 10%) is attributed to sea surface wind errors (+/-10%) that induce similar ocean wave height errors. Thus, a +/- 10% error in ocean wave height with a measurement range of 0.5-30 m will roughly yield a measurement accuracy of +/-0.3 m.

Commandant of the Marine Corps letter "*Validation and Submission of Marine Corps Meteorology, Oceanography (METOC) and Mapping Charting and Geodesy (MC&G) Environmental Requirements*" of 01 Aug 1996.

(USA) IAW FM 34-81-1, sea state condition knowledge is required by Army engineers as it affects site selection and the operations of port and beach facilities.

(DOC) Thresholds are consistent with DOC requirements for future forecast model improvements resulting from direct assimilation of wave measurements, described in NOAA Polar-Orbiting Satellite Requirements Study, DOC, 1990; and in Ocean-Atmosphere Observations Supporting Short-Term Climate Predictions, National Academy Press, 1994. The measurement of significant wave height from space has been adequately demonstrated by a number of satellites.

Parameter 8.9--Surf Conditions (DoD). (USN) Accurate knowledge of surf conditions is a primary requirement for amphibious operations and must be known to enhance war-fighting capabilities. Besides knowing the Breaker type, the USMC also requires knowledge of breaker height, surf direction, surf height, surf zone length, surf zone width, surf breaker line and surf plunge point. This combination of parameters provides the Marine Expeditionary Unit (MEU) Commander with the knowledge needed to impact the "go/no go" decision to commit forces to an amphibious operation. Without sufficient knowledge of surf conditions, any amphibious operation is at risk of failure.

Commandant of the Marine Corps letter "*Validation and Submission of Marine Corps Meteorology, Oceanography (METOC) and Mapping Charting and Geodesy (MC&G) Environmental Requirements*" of 01 Aug 1996.

Parameter 8.10--Bathymetry (Deep Ocean and Near Shore) (DoD). (USN) When naval forces approach a denied coastline, they require full knowledge of the depth of water for safety for the full-spectrum of operations. Satellite sensing can provide a first approximation to the bathymetry to allow operational commanders to focus available resources to those areas deemed favorable through satellite remote sensing techniques. This applies for deep ocean and near shore approaches to the denied coastline.

Commandant of the Marine Corps letter "*Validation and Submission of Marine Corps Meteorology, Oceanography (METOC) and Mapping Charting and Geodesy (MC&G) Environmental Requirements*" of 01 Aug 1996.

Parameter 8.11--Salinity (DoD/DOC). (DOC/USN Ocean Observer Requirements Team) There has been a growing awareness among the research and operational oceanography communities of the important role that surface salinity variability plays in ocean and climate dynamics. The primary motivation is that both short term circulation forecasts and climate scale predictions depend heavily on the salinity field and its variability. One of the major technical obstacles for working in this microwave band is the need for very large antenna structures in order to obtain high spatial resolution. Footprint size is inversely proportional to antenna aperture, and 10-20 m apertures are required for a ~10 km footprint size, depending on orbit altitude. However, as described below, key questions can be addressed with data of much coarser resolution attainable with smaller antennae. Indeed, NASA has already undertaken preliminary system studies for such a salinity satellite. Thus, we are now at a time when such systems are becoming affordable, the scientific and operational needs are becoming sufficiently compelling, and adequate technology is becoming available.

The SSIWG has recommended three broad primary scientific objectives for SSS remote sensing:

1. Improving seasonal to interannual [ENSO] climate predictions: This involves the effective use of SSS data to initialize and improve the coupled climate forecast models, and to study and model the role of freshwater flux in the formation and maintenance of barrier layers and mixed layer heat budget in the tropics.

2. Improving ocean rainfall estimates and global hydrologic budgets: Precipitation over the ocean is still poorly known and relates to both the hydrologic budget and to latent heating of the overlying atmosphere. The "ocean rain gauge" concept shows considerable promise in reducing uncertainties on the surface freshwater flux on climate time scales, given SSS observations, surface velocities and adequate mixed layer modeling.

3. Monitoring large scale salinity events: This may include ice melt, major river runoff events, or monsoons. In particular, tracking interannual SSS variations in the Nordic Seas is vital to long time scale climate prediction and modeling. High latitude SSS variations influence the rate of oceanic convection and poleward heat transport. These measurements will also be the most

technically challenging because of the SSS accuracy needed, and the relatively weaker radiometric signature at low sea temperature.

Salinity signals are much stronger in the coastal ocean and marginal seas than in the open ocean in general, but the anticipated large footprint size will limit near shore applications of the data. The SSS data required for the three objectives listed above will lead to significant improvements in global models which, in turn, provide boundary conditions for nested regional and coastal models. Thus, while observation of small-scale coastal structure may not be possible with a first generation salinity satellite, improvement in prediction of coastal variability is anticipated.

Many of the larger marginal seas which have strong SSS signals should be adequately resolved, such as the East China Sea, Bay of Bengal, Gulf of Mexico and Coral Sea/Gulf of Papua.

To formulate specific requirements to meet the objectives described above, the following four problems were posed and associated accuracy, spatial and temporal requirements were developed:

1. Barrier layer effects on tropical Pacific heat flux
   0.2 psu 100 km 30 days
2. Halosteric adjustment of heat storage from sea level
   0.2 psu 200 km 14 days
3. N. Atlantic thermohaline circulation
   0.1 psu 100 km 30 days
4. Surface freshwater flux balance
   0.1 psu 300 km 30 days

The North Atlantic thermohaline circulation and convection in the sub-polar seas has the most demanding requirements, and is the most technically challenging because of the lower brightness/SSS ratio at low water temperatures. It thus defines the threshold requirements for global horizontal resolution and measurement precision. It's lower demand on refresh rate permits more temporal averaging which should allow the measurement accuracy and precision requirements to be met.

Parameter 8.12--Oil Spill Location (DOC). The required products are all-weather, day/night, high-resolution maps of oil spills on the ocean, on lakes, and on larger rivers. Only regional coverage is required for selected monitoring areas. Tasking must be rapid (24 hours or less) to respond to spills as they occur in U.S. waters and other regions of interest worldwide. The threshold output product is an oil/no oil determination on a map. The objective output product further distinguishes between biogenic and mineral oil.

Parameter 9--Vertical Hydrometeor Profile (DOC). The requirement is for a vertical profile of precipitating water and precipitating ice (mean in volume).

Parameter 10--Neutral Winds (DoD/DOC). The Space Environmental Parameters have threshold values established in a joint DOC/DoD study, "Space Environmental Monitoring Requirements For Polar Orbiting Spacecraft." These parameters shall be measured continuously in each orbital plane, at specified resolutions, to get a representative sampling of the ionosphere, which is itself semi-sun-synchronous. In addition, equal spacing, and adequate coverage of the dawn/dusk transitions and the approximate noon/midnight fluctuations are necessary. One exception to these requirements is the solar EUV flux, which is obtained by viewing the sun directly.