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NOAA's Mission Requirements Document 2A (MRD-2A) for the GOES-R Series

ID: 2

Version 2.3, March 19, 2004

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1. INTRODUCTION

ID: 313

1.1 PURPOSE

ID: 314

This updated version of the Mission Requirements Document (MRD) called MRD-2A was prepared by the NOAA's National Satellite, Data, and Information Service (NESDIS) and describes the National Ocean and Atmospheric Administration's (NOAA's) plan for implementation of the Geosynchronous Operational Environmental Satellite (GOES)-R Series System. The MRD-2A addresses the geosynchronous-earth-orbit (GEO) needs of NOAA, as described in the GOES Program Requirements Document - 1 final draft (GPRD-1fd). The GPRD-1fd reflects NOAA's users needs and updates the Geosynchronous Operational Requirements Document I (GORD-I) released December 2, 2002. The MRD-2A details NOAA's requirements to any acquisition agency. Subsequent lower level documents written by any acquisition agency will reflect NOAA's needs to the vendors.

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The MRD is also an evolving document. It was originally released on December 6, 2002 as the MRD-I. It was updated in MRD-1A and was released on July 17, 2003. This MRD-2A will be updated with three more planned versions, MRD-2B, MRD-2C, and MRD-2D, in approximately the next three years. This current update of February 2004 occurs after the Formulation Phase for the Advanced Baseline Imager (ABI) and before the Implementation Phase but during the Broad Agency Announcement (BAA) for the GOES Architecture Studies. Subsequent MRD updates will both reflect NOAA's plans after receiving the results of both end-to-end system architecture studies and other individual formulation studies and include any requirement updates from subsequent GPRDs. The future MRDs will then provide the updated requirements for the respective Implementation Phase of the procurements. The next MRD, MRD-2B will update the space and solar instrument suites (SIS and SEISS) parameters', nominally in May 2004. The MRD-2C will update the Hyperspectral Environmental Suite and the SIS and SEISS implementations nominally in November 2005. The MRD-2D will occur nominally in May 2006, after the final spacecraft trades. All MRD updates will reflect improved understanding of the appropriate implementation approach that will become apparent through the trade-study processes for the payloads, the spacecraft, and the GOES-R series constellation.

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(Throughout this document, "will" implies a fact, while "shall" implies a requirement. Subsequent version of the MRD will use shall for all requirement, but this version does not yet contain that correction. All instrument requirements contain at least the word (THRESHOLD) and may contain the word GOAL, distinguishing between the necessary and the desirable requirements.

ID: 317

The GOES-R Series represents a very significant improvement over the capabilities of both current series of GOES satellites. The GOES-R series will meet the more demanding GPRD-1fd requirements, unlike the current GOES I and N series. Therefore, more of the weather monitoring and environmental monitoring needs of NOAA will be addressed. The GPRD-1fd requirements are included in this document (and associated appendix). The requirements included in the shortfalls section of this document will not be met in the GOES-R series due to limited resources, whether temporal or financial. The requirements in the pre-planned product improvement (P^3I) section may not be met in the first satellite(s) in the GOES-R series, but may be met by planned improvements during the GOES-R series.

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The MRD contains threshold and goal performance parameters. The threshold performance parameters represent a starting point for the GOES-R series. If the performance can be improved by making it closer to the goal value by either P^3I or another means, the improvement is desirable from a benefits point of view. The usage of threshold and goal values rather than only goal values is again related to resource limitations.

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Requirement parameters in this MRD that differ from those in the GPRD-1fd take precedent over those in the GPRD-1fd because this document describes the plan for implementation. This can occur when the GPRD-1fd describes a need that will not be completely fulfilled by the anticipated GOES-R launch date of 2012. Specifically, the requirements in the MRD may describe a goal value that is reduced compared to that of the GPRD-1fd. As described above, this may be due to resource limitations. It may also be due to limitations imposed by physics and technology. In each circumstance, if the constraint is not financial, temporal, or due to physics and technology, it is believed there is not a significant impact from these implementation choices.

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1.2 DOCUMENT ORGANIZATION

ID: 321

This MRD contains sections that have previously been called technical requirements documents. These sections and subsections can be separated out to the appropriate agencies at the designated the time. The document has 5 sections: Space-Located Segment; Ground-Located Communications, Command, and Control Segment; Product Generation and Distribution Segment; Archive and Access Segment, and User Interface Segment. Between each of these sections, there will be an interface. The details of each interface will be detailed in separate Interface Documents not contained in this version of the MRD. The Space-located Segment described in Section 2 includes the spacecraft, the instruments, the entire communications payload services located on the spacecraft, the on-board processing systems that feeds the instrument data to the communications system and in parallel feeds the telemetry and command information to the communications system, and the launch vehicle. The Ground-Located Communications, Command, and Control Segment described in Section 3 includes the data downlink system, the retransmission hardware for the GOES Rebroadcast (GRB), the ground facilities that perform the functions of telemetry and raw data processing including calibration, navigation and registration, and the Satellite Operations Control Center. The Product Generation and Distribution Segment, described in Section 4, includes processing of data (using predefined algorithms) starting with the level 1b (calibrated, navigated, registered) and ending with derived products. The derived products are distributed to user ports, namely the NOAA's National Weather Service (NWS) and other users. This section describes algorithms, hardware, and supports requested from other NOAA line offices. The Archive and Access Segment, described in Section 5 below, includes the integration of the GOES data and products into the Comprehensive Large Array-data Stewardship System (CLASS) system and the implementation details under discussion for that system for storage and retrieval of GOES measurements. The User Interface Segment described in Section 6 below includes education and training plans for the users to facilitate usage of the larger, richer products sets available from the GOES-R series. Outreach to the general public is also discussed in the section.

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1.3 REFERENCE DOCUMENTS

ID: 323

As mentioned in section 1.1 of this document, this document addresses the geostationary observational requirements of NOAA that will be implemented in the GOES-R Series. These geostationary observational requirements are described in the "Program Requirements Document for the Follow-on Geostationary Operational Environmental Satellite System (GOES-R Series)" final draft, or GPRD-1fd, updated in June 2003 and in January, 2004. The GPRD will also be updated in the future with subsequent versions (GPRD-1 and GPRD-2) to support reviews within NOAA.

ID: 324

The documents, formerly known as the Technical Requirements Documents for each instrument and any segment, have been incorporated into this document. Thus any numbers in this document supersede those older documents.

ID: 325

1.4 MISSION

ID: 6021

Program Overview

United States Code Title 15 Chapter 9 has chartered Department of Commerce to forecast weather, issue storm warnings, and display weather and flood signals that will benefit agriculture, commerce, and navigation. National Oceanic and Atmospheric Administration's (NOAA) primary environmental mission is to provide forecasts and warnings for the United States, its territories, adjacent waters and ocean area, for the protection of life and property and the enhancement of the national economy. To achieve this, multiple observation platforms have been developed and are used daily to derive products that are used in protecting estuaries farmlands, endangered species, maritime, air, and ground transportation systems, and property. One observational platform is the NOAA Space-based Observation System, which includes the GOES, POES, and NPOES Satellite Systems, providing forecasters with short and long term forecast.

The GOES satellites are stationary, located at 75° and 135° W (with potential for movement to 137° W) in GEO. GOES-R satellite will provide capabilities for full disk imagery, with simultaneous (concurrent) CONUS and Mesoscale environmental imagery and sounding coverage over a large portion of the full disk down to mesoscale regions. This information is used for short term forecasting (as well as longer term forecasting), whereas, the POES and NPOES satellites orbit the earth in polar LEO orbit, with data refresh every ~4-6 hours in general, providing global observations leading to long term forecast. The National Weather Service (NWS) uses information derived from both satellite systems to derive additional warning times in cases of major storms and severe events.

The GOES satellites provide an uninterrupted flow of data processed through the ground infrastructure (end-to-end system) to forecasters in the NWS, other international, federal, state, and local governments, universities, and private organizations. These data are processed and assimilated into numerical forecast models that assist in forecasts ranging temporally from daily to extended forecasts, and to severe weather early watches and warnings.

The GOES-R System Mission Operations Center activity includes operations, monitoring, maintaining, acquiring, processing, distributing and storing data from GOES-R satellites. This includes:

- Monitoring satellite health and safety;
- Rapid collection, processing and analysis;
- Scheduling satellite operations and data acquisition to meet GOES-R user needs;
- Evaluating satellite systems performance;
- Commanding the spacecraft;
- Assessing satellite and ground station anomalies;
- Data ingestion, product processing, and distribution of GOES-R data;
- Receiving, compiling, archiving, and disseminating GOES-R data and products out through the GOES users interface.

Planned GOES improvements in the GOES-R timeframe will cross cut NOAA's four mission goals (ecosystems, weather/water, climate, and commerce). GOES-R will also provide significant enhancement to (when compared to GOES-N products) NOAA's ability to meet the short-term environmental sensing needs (improved weather event lead-times and more distinct effected areas) by an advancing sensor sensitivity to the detection of atmospheric moisture and improving the understanding of storm development of derived winds, which leads to a more dynamic numerical model performance accuracy. Synergized information will drive earlier predictions, more precise forecast, and precision area to be effected which will support a positive economic impact through dollar savings. GOES-R series acquisition consists of technology advancements in instruments and end-to-end infrastructure for the following: atmospheric, solar, and ground environmental measurements through imaging and sounding; water (streams and rivers) level data collection through the Data Collection Platforms (DCP's); command, control and communications; product generation and distribution and reprocessing, and archive/access, up through the user interface. The GOES-R improvements solidly support NOAA's mission, "to understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet our Nation's economic, social, and environmental needs." The first launch is scheduled for 2012 and the system will be operational through 2030 (TBS).

The GOES-R system provides an observation system that produces reliable data on atmosphere, terrestrial, land, fresh water, and ocean ecosystems data and will be one of the primary USA systems networked into the Global Observing System led by the World Meteorological Organization and that was set as a goal at the Earth Observation Summit (July 2003).

Constraint. Implementation of the advanced ground system capability cannot degrade current capabilities or impede the transmission of information to current users from current satellites.

ID: 6312

Mission Objectives

Primary Mission Objectives

To maintain GOES mission continuity and quality in environmental observations in the 2012-2030 timeframe.

To provide enhanced environmental data products

To improve services and data being provided to Users

To be responsive to technology infusion to meet evolving User needs

To protect, restore, and manage the use of coastal and ocean resources through ecosystem management approaches

To understand climate variability and change to enhance society's ability to plan and respond

To serve society's need for weather and water information

To support the Nation's commerce with information for safe and efficient transportation

Secondary Mission Objective

To support ties to the NOAA/National/International Observing System

ID: 326

1.4.1 General Mission Description

ID: 327

The GOES-R Series Mission will have the following general characteristics that are detailed elsewhere in the document.

ID: 328

Currently, the GOES-R series of satellites will make observations from geostationary orbit and will view the Western Hemisphere.

ID: 329

Based on initial studies, it is currently anticipated that the approach for the GOES-R series of satellites will be multiple satellites described in sections 2.3.1. However, an end-to-end system architecture study will supply data to make a final determination on this topic.

ID: 330

The satellites will be controlled from NOAA facilities on the ground.

ID: 331

The instruments supported by the spacecraft will provide measurements of environmental data and will transmit this data to the ground stations.

ID: 332

Products will be generated from the calibrated, registered, and navigated data. The products generated from each instrument are detailed in the front of each instrument section of this document.

ID: 333

Products will be made available to all users.

ID: 334

A subset of the data complete with the calibration, registration, and navigation corrections are distributed directly to some users. A subset is being considered because the amount of data will be higher that the current series due to the larger coverage areas and faster coverage rates. The exact form of the subset is still under review.

ID: 335

The full data sets will also be archived for access by present and future users.

ID: 336

Educational opportunities will exist for users who desire training.

ID: 337

Public outreach plans will be developed.

ID: 338

1.4.2 Mission Schedules and Need Dates

ID: 339

The GOES-R series will become operational nominally starting in 2012. The current schedule is shown here. This schedule is still evolving and is subject to change.

ID: 5775

<Picture>

Spacecraft	Spacecraft availability date (draft)	Spacecraft Launch Date (draft)
GOES-N	Dec. 2004	Dec. 2004
GOES-O	Dec. 2005	Apr. 2007
GOES-P	Apr. 2007	Oct. 2008
GOES-R	Oct. 2012	Oct. 2012
GOES-S	Apr. 2013	Apr. 2014

ID: 361

1.4.3 Mission Requirements Crossing All Segments

ID: 367

1.4.3.1 Maintenance

ID: 368

All maintenance will be performed with no operational disruption on fulfillment of any requirements.

ID: 369

All segments will support maintenance of operational interfaces with other applicable GOES R Segments.

ID: 364

1.4.3.2 End-to-End Validation

ID: 365

End-to-end validation is required for each segment.

ID: 366

End-to-end validation is required for the entire GOES-R system.

ID: 362

1.4.3.3 Mission Security

ID: 363

Mission Security will be maintained for all segments.

ID: 370

1.4.3.4 Configuration Management and Documentation

ID: 371

1.4.3.4.1

ID: 372

1.4.3.4.1.1 Configuration Management

ID: 373

All Segments shall maintain configuration control of hardware, software, and databases.

ID: 374

There shall be an end-to-end GOES-R Configuration Management Plan that will maintain configuration control of interfaces between segments.

ID: 375

Each Configuration Management Plan is subject to Government approval.

ID: 376

1.4.3.4.1.2 Documentation

ID: 377

All Segment hardware and software shall be described in appropriate documentation, including Interface Control Documents (ICDs).

ID: 378

1.4.3.5 Reliability

ID: 379

All Segments as a system shall deliver (TBD) level of reliability. Reliability shall take into account both software and hardware.

ID: 6019

1.4.3.6 Availability

ID: 6020

System Availability is the probability that a system can be successfully used for any specified mission over the stated period of time and is defined as the Mean Time Between Failure (MTBF) divided by the sum of the MTBF and the Mean Time To Repair (MTTR) (nominally uptime divided by the sum of the uptime and downtime).

The system availability over the operational lifetime shall be 0.82 (TBR). The system availability on a monthly basis shall be (TBD). The system shall support the data collection, downlink, and creation of GPRD critical user products over CONUS 99% of the time, which is the equivalent of downtime of 0.304 days per month. The system shall support the data collection, downlink, and creation of other GPRD as the coverage of the system affords.

ID: 380

1.4.4 Mission Requirements Crossing Multiple Segments

ID: 381

1.4.5 Mission data latency

ID: 382

Mission data latency from the time the data is collected to the time that the data is converted to a product is product dependent. The data latency varies by product and is recorded with each product in the front section of each instrument supporting that product determination. However, a common data latency requirement is one minute (TBR) for some ABI products. The most restrictive data latency in the GPRD-1fd is 30 seconds, which applies for mesoscale (1000 km x 1000 km) cloud and moisture imagery. Both the one minute and the 30 second latency requirements shall be divided across the multiple segments in the following ways: for the 30 second requirement-10 sec (TBR) for the space segment; 10 seconds (TBR) for the ground-located communication, command, and control segment; and 10 seconds (TBR) for the product generation and distribution system and for the 1 minutes requirement-10 seconds (TBR) for the space segment; 10 seconds (TBR) for the ground-located communication, command, and control segment, and 40 seconds (TBR) for the product generation and distribution segment

ID: 383

1.4.6 Mission Lifetime and Reliability

ID: 384

The mission will provide data and products until the year 2030 (TBS). The mission reliability shall be TBD.

ID: 385

1.4.7 General Mission Observational Requirements

ID: 386

The observational requirements that are met by this MRD are derived from those in the GPRD-1fd. With the GOES-R series, NOAA has made an effort to address needs beyond the GOES-I and -N series. Imagery and sounding data will be collected with significantly improved spatial and spectral resolution at faster coverage rates over comparable or larger areas. In particular the sounding and imagery rates have been greatly expanded which reduces the conflict between sensing multiple areas of interest in a limited time frame with one instrument.

ID: 387

More complete coverage of weather and environmental events, including sounding through clouds, remains a goal of the GOES-R series to meet the needs of NOAA's NWS. Currently, the instrumentation to do this will be investigated as part of pre-planned product improvement (P^3I) efforts. P^3I efforts are described separately in section 2.11.4.

ID: 388

Monitoring of the short-term variations of the environment will be addressed by GOES-R. Coastal zone coverage at higher spatial resolution is also addressed employing about 0.3 km spatial resolution coverage in dedicated bands in the performance requirements. Many land, aerosol, and ocean products are also new and will be addressed by GOES-R, expanding the capabilities of GOES.

ID: 389

Improvement of solar and space weather sensing to observe solar and space environment variability are planned for GOES-R, with new capabilities under investigation that extend spectral coverage to shorter wavelengths, increase energy measurement ranges, and address the possibility of new measurement types.

ID: 390

The GPRD-1fd has divided the remote sensing needs of NOAA into the following categories: atmospheric, land, ocean, and space and solar. The atmospheric category includes the needs of NOAA's NWS, which contains predominantly the observational requirements from the older NOAA's NWS-Operational Requirements Document (ORD). The Land requirements contain requirements on land surface measurements. The oceans category from the GPRD-1fd contains requirements on coasts and oceans. This document includes solar and space requirements in one category called space weather that contains needs for the current Space Environmental Monitoring capability as well as additional solar and energetic particle monitoring in earth's magnetosphere.

ID: 391

The GPRD-1fd products, as they exist at the time of writing this MRD-2A, that will be met by the GOES-R series are listed below. These are not the MRD-2A level requirements but are the inputs to the MRD. The MRD requirements are detailed throughout the text of this document. The GPRD-1fd requirements are recorded for traceability and are listing in the appendix to this document. (It is important to note that all TBS values listed in appendix A are "To Be Supplied by the government". The GOES Program office will be maintaining control over the supplied values. Many of these values will require detailed study over the period of several years to assess the capability of the system, particularly when TBS was used for measurement accuracy values.)

Because the product names are inputs to the MRD from the PRD, the user supplied product name has been used. Thus the user supplied term Hemispheric is met by the ABI data from full disk views of the earth (out to the earth's limb for some products including qualitative cloud drift winds and out to about 70 degree LZA for more quantitative product) and is addressed by HES out to 62 degree local zenith angle for retrievals (or slightly beyond as radiative transfer models improve). Users are aware that full disk data will be produced from the ABI and that HES data required outside of the 62 degree LZA may require longer than 1 hour to collect at the coverage rate of 62 degree LZA/hour. For emphasis the usage of hemispheric in quotes in applied when the primary instrument for the product is HES.

ID: 392

Within the table below is a partitioning of the products by instrument. Note that the usage of coastal and offshore are included in the definition for coastal used for HES.

ID: 393

Section 2.11.3 discusses any shortfalls in meeting NOAA's needs as described in the GPRD-1fd and provided some valuable comments on the products. That section also includes a discussion of any variation between the requirements of the GPRD-1fd and the planned implementation, and justification for that implementation. Section 2.11.4 describes P^3I efforts.

ID: 394

1.4.7.1 GPRD-1fd Atmosphere

AEROSOLS	
Aerosol Particle Size	ABI

Aerosol Detection: CONUS (including Smoke and Dust)	ABI
Aerosol Detection: Hemispheric (including Smoke and Dust)	ABI
Aerosol Detection: Mesoscale (including Smoke and Dust)	ABI
Dust/Aerosol: Loading: CONUS	HES-DS, ABI must help
Dust/Aerosol: Loading: “Hemispheric”	HES-DS, ABI will help
Suspended Matter: CONUS	ABI
Suspended Matter: “Hemispheric”	ABI
Volcanic Ash	ABI, HES-SW/M must help
CLOUDS	
Aircraft Icing Threat	HES-DS
Cloud Imagery: Coastal	ABI: Day, HES-CW will help:Day ABI: Night
Cloud & Moisture Imagery: CONUS	ABI
Cloud & Moisture Imagery: Hemispheric	ABI
Cloud & Moisture Imagery: Mesoscale	ABI
Cloud Base Height: CONUS	HES-DS
Cloud Base Height: “Hemispheric”	HES-DS
Cloud Base Height: Mesoscale	HES-SW/M
Cloud Ice Water Path: CONUS	ABI
Cloud Ice Water Path: Hemispheric	ABI
Cloud Ice Water Path: Mesoscale	ABI
Cloud Layers/ Heights and Thickness: CONUS	HES-DS and ABI
Cloud Layers/ Heights and Thickness: “Hemispheric”	HES-DS and ABI
Cloud Layers/ Heights and Thickness: Mesoscale	HES-SW/M and ABI
Cloud Liquid Water: CONUS	ABI
Cloud Liquid Water: Hemispheric	ABI
Cloud Liquid Water: Mesoscale	ABI
Cloud Optical Depth: CONUS	ABI
Cloud Optical Depth: Hemispheric	ABI
Cloud Particle Size Distribution: CONUS	ABI and HES-DS helps
Cloud Particle Size Distribution: Hemispheric	ABI and HES-DS helps
Cloud Particle Size Distribution: Mesoscale	ABI
Cloud Phase: CONUS	ABI
Cloud Phase: Hemispheric	ABI
Cloud Phase: Mesoscale	ABI

Cloud Top Height: CONUS	HES-DS, ABI helps
Cloud Top Height: “Hemispheric”	HES-DS, ABI helps
Cloud Top Height: Mesoscale	HES-SW/M, ABI helps
Cloud Top Pressure: CONUS	HES-DS and ABI
Cloud Top Pressure: “Hemispheric”	HES-DS and ABI
Cloud Top Temperature: Hemispheric	ABI and HES-DS helps
Cloud Top Temperature: Mesoscale	ABI and HES-SW/M helps
Cloud Type: CONUS	ABI and HES-DS helps
Cloud Type: Hemispheric	ABI
Cloud Type: Mesoscale	ABI and HES-SW/M helps
Convective Initiation	ABI and HES-SW/M
Enhanced "V"/Overshooting Top Detection: CONUS	ABI and HES-SW/M helps
Enhanced "V"/Overshooting Top Detection: Mesoscale	ABI and HES-SW/M helps
Hurricane Intensity	ABI
Imagery: All-Weather/Day-Night Hemispheric	ABI and P^3I GMS
Imagery: All-Weather/Day-Night: Hemispheric	ABI and P^3I GMS
Lightning Detection: CONUS	GLM
Lightning Detection: Hemispheric	GLM
Lightning Detection: Mesoscale	GLM
Low Cloud and Fog	ABI
Turbulence: Hemispheric	ABI and HES-DS helps
Turbulence: Mesoscale	ABI and HES-SW/M helps
Visibility: Coastal	ABI and HES-CW
Visibility: Hemispheric	ABI
PRECIPITATION	
Removed	Removed
Removed	Removed
Removed	Removed
Removed	Removed
Removed	Removed
Removed	Removed
Probability of Rainfall	ABI
Rainfall Potential	ABI and Micro and HES-DS helps
Rainfall Rate/Quantitative Precipitation Estimate	ABI

PROFILES	
Atmospheric Vertical Moisture Profile: CONUS	HES-DS
Atmospheric Vertical Moisture Profile: "Hemispheric"	HES-DS
Atmospheric Vertical Moisture Profile: Mesoscale	HES-SW/M
Atmospheric Vertical Temperature Profile: CONUS	HES-SW/M
Atmospheric Vertical Temperature Profile: "Hemispheric"	HES-DS
Atmospheric Vertical Temperature Profile: Mesoscale	HES-SW/M
Capping Inversion Information: CONUS	HES-DS
Capping Inversion Information: Mesoscale	HES-SW/M
Derived Stability Indices: CONUS	ABI and HES-DS
Derived Stability Indices: Mesoscale	ABI and HES-SW/M
Moisture Flux: CONUS	HES-DS and HES-SW/M and ABI
Moisture Flux: "Hemispheric"	HES-DS and ABI
Moisture Flux: Mesoscale	HES-SW/M and ABI
Surface Pressure: Mesoscale	HES-SW/M and GMS helps
Pressure Profile: Mesoscale	HES-SW/M helps
Total Precipitable Water: "Hemispheric"	HES-DS
Total Water Content: CONUS	HES-DS
Total Water Content: "Hemispheric"	HES-DS
Total Water Content: Mesoscale	HES-SW/M
RADIANCES	
Clear Sky Masks: CONUS (depends on instrument)	ABI or HES-DS or and/or HES-CW
Clear Sky Masks: Hemispheric	ABI or HES-DS
Clear Sky Masks: Mesoscale	ABI or HES-SW/M
Radiances: CONUS	HES-DS
Radiances: "Hemispheric"	HES-DS
Radiances: Mesoscale	HES-SW/M
RADIATION	
Absorbed Shortwave Radiation: Surface/ Hemispheric	ABI makes proxy
Absorbed Shortwave Radiation: Surface/ Mesoscale	ABI makes proxy
Downward Longwave Radiation: Surface/CONUS	ABI and HES make proxy
Downward Longwave Radiation: Surface/Hemispheric	ABI and HES make proxy
Downward Solar Insolation: Surface/ CONUS	ABI, HES helps
Downward Solar Insolation: Surface/ Hemispheric	ABI, HES helps

Downward Solar Insolation: Surface/ Mesoscale	ABI, HES helps
Reflected Solar Insolation: TOA / CONUS	ABI, HES helps
Reflected Solar Insolation: TOA / Hemispheric	ABI, HES helps
Upward Longwave Radiation: Surface/CONUS	HES-DS
Upward Longwave Radiation: Surface/"Hemispheric"	HES-DS
Upward Longwave Radiation: TOA/ CONUS	HES-DS
Upward Longwave Radiation: TOA/ "Hemispheric"	HES-DS
TRACE GASES	
Removed	Removed
CO Concentration	HES-DS
Removed	Removed
Ozone Layers: CONUS	HES-DS
Ozone Layers: "Hemispheric"	HES-DS
Ozone Total: CONUS	ABI
Ozone Total: "Hemispheric"	ABI
SO_2 Detection only	ABI
WINDS	
Derived Motion Winds: CONUS	ABI and HES-DS helps
Derived Motion Winds: Hemispheric	ABI and HES DS-helps
Derived Motion Winds: Mesoscale	ABI and HES-SW/M helps
Microburst Winds	ABI and HES-SW/M

ID: 771

1.4.7.2 GPRD-1fd Oceans

Currents: Hemispheric	ABI, HES-OO may help
Currents: Mesoscale	ABI, HES-CW
Currents: Offshore / CONUS	ABI, HES-CW, HES-OO
Currents: Offshore / Hemispheric	ABI, HES-OO may help
Ocean Color: Coastal (Turbidity/Chlorophyll/ Reflectance)	HES-CW
Ocean Color: CONUS/Offshore (Turbidity/Chlorophyll/ Reflectance)	HES-CW
Ocean Color: Offshore (Turbidity/Chlorophyll/ Reflectance) -- Hemispheric	HES-OO
Ocean Turbidity: "Hemispheric" (Turbidity/Visibility)	HES-OO

Optical Properties: Coastal (particulate absorption, backscatter, fluorescence)	HES-CW
Optical Properties: CONUS/Offshore (particulate absorption, backscatter, fluorescence)	HES-CW
Sea & Lake Ice/Age: CONUS	ABI primarily, or HES-CW
Sea & Lake Ice/Age: Hemispheric	ABI primarily, or HES-OO
Sea & Lake Ice/Concentration: CONUS	ABI
Sea & Lake Ice/Concentration: CONUS	ABI
Sea & Lake Ice/Concentration: Hemispheric	ABI
Sea & Lake Ice/ Displacement and Direction: CONUS	ABI
Sea & Lake Ice/ Displacement and Direction: Hemispheric	ABI
Sea & Lake Ice/Extent and Characterization: CONUS	ABI
Sea & Lake Ice/Extent and Characterization: Global	ABI
Sea & Lake Ice/Extent and Characterization: Hemispheric	ABI
Sea & Lake Ice/ Motion: CONUS	ABI
Sea & Lake Ice/ Motion: Hemispheric	ABI
Sea & Lake Ice: Surface Temperature	ABI
Sea & Lake Ice/Surface Temperature: CONUS	ABI
Sea & Lake Ice/Surface Temperature: Hemispheric	ABI
Sea Surface Temperature: Coastal	ABI, HES-CW may help (goal) and P^3I
Sea Surface Temperature: CONUS/Offshore	ABI, HES-CW may help (goal)
Sea Surface Temperature: Hemispheric	ABI
Sea Surface Temperature: Mesoscale	ABI, HES-CW may help (goal)

ID: 851

1.4.7.3 GPRD-1fd Land

Fire / Hot Spot Imagery: CONUS	ABI
Fire / Hot Spot Imagery: Hemispheric	ABI
Flood/Standing Water: Hemispheric	ABI, HES-DS, and HES-CW could help
Flood/Standing Water: Mesoscale	ABI, HES-SW/M, and HES-CW could help
Ice Cover/ Landlocked: Hemispheric	ABI
Land Surface (Skin) Temperature: CONUS	ABI and HES-DS helps

Land Surface (Skin) Temperature: Hemispheric	ABI and HES-DS helps
Land Surface (Skin) Temperature: Mesoscale	ABI and HES-DS helps
Removed	Removed
Snow Cover: CONUS	ABI
Snow Cover: Hemispheric	ABI
Snow Cover: Mesoscale	ABI
Snow Depth over Plains: CONUS	ABI
Snow Depth over Plains: Hemispheric	ABI
Snow Depth over Plains: Mesoscale	ABI
Surface Albedo: Hemispheric	ABI
Surface Emissivity	HES-DS
Vegetation Fraction: Green	ABI, HES-CW could help
Vegetation Index: CONUS	ABI, HES-CW could help
Vegetation Index: Hemispheric	ABI, HES-CW could help

ID: 913

1.4.7.4 GPRD-1fd Space Weather (Space and Solar)

Energetic Particles	
Energetic Heavy Ions	SEISS: EHIS
Magnetospheric Electrons and Protons: Low Energy	SEISS: MPS
Magnetospheric Electrons and Protons: Medium and High Energy	SEISS: MPS
Solar and Galactic Protons	SEISS: SGPS
Magnetic Field	
Geomagnetic Field	Magnetometer
Solar	
Solar Flux: EUV	SIS: EUVS
Solar Flux: X-ray	SIS: XRS
Solar Imagery: X-Ray	SIS: SXI

ID: 948

1.4.6.5 Pre-Planned Product Improvement Products

ID: 949

Pre-Planned Product Improvement (P^3I) products are discussed in section 2.11.4 and listed at the end of that section.

ID: 950

1.4.8 Mission Continuity

ID: 951

The Mission shall conform to the NOAA-NESDIS Continuity of Operations Plan (COOP) providing policy, guidance, and procedures that ensure, in the event of emergencies or threat of an emergency, both the preservation of data and continuity of operations.

ID: 952

2. SPACE-LOCATED SEGMENT

ID: 953

2.1 IMPLICATIONS OF MISSION REQUIREMENTS CROSSING ALL SEGMENTS

ID: 954

2.1.1 Mission security in this segment

ID: 955

Mission security will be maintained in the space-located segment.

ID: 956

2.1.2 End to end validation in this segment

ID: 957

End to end validation of each of the instruments is required.

ID: 958

Spacecraft and instruments end-to-end validation tests shall be performed during the pre-launch period to demonstrate full operational capabilities for each phase of the GOES-R mission.

ID: 959

2.1.3 Configuration Management and Documentation

ID: 960

2.1.3.1 Configuration Management

ID: 961

The Segment shall maintain configuration control of hardware, software, and databases.

ID: 962

The Segment Configuration Management Plan shall be developed.

ID: 963

2.1.3.2 Documentation

ID: 964

All Segment hardware and software shall be described in appropriate documentation, including Interface Control Documents (ICDs).

ID: 965

2.1.4 Reliability

ID: 966

The Segment shall deliver (TBD) level of reliability.

ID: 967

2.2 IMPLICATIONS OF MISSION REQUIREMENTS CROSSING MULTIPLE SEGMENTS

ID: 968

2.2.1 Data latency in this segment

ID: 969

Data latency between the detection of the earth signal to the initiation of data transmission is TBS.

ID: 970

2.2.2 Maintenance

ID: 971

TBD

ID: 972

2.2.3 Removed

ID: 973

TBD

ID: 974

2.3 SATELLITES IN CONSTELLATION

ID: 975

2.3.1 Constellation Description and Definitions

ID: 976

2.3.1.1 Consolidated versus Distributed Architecture

ID: 977

There will be multiple satellites in the GOES constellation. A satellite consists of a spacecraft to hold the instruments, the associated communication systems, and the communications payload services. The minimum number of operational satellites is two. Several satellite architectures, and thus constellation architectures, are under consideration. Two primary architectures that are being considered are the consolidated architecture and the distributed architecture. The consolidated architecture uses two satellites, which is similar to the architecture for the current GOES. A distributed architecture consists of two or more satellites at each operational location, providing the same functions as a single consolidated satellite. The consolidated architecture supplies all payloads in a single satellite whereas the distributed architecture distributes the payloads across several satellites. The distributed architecture is the current Notional Baseline Because the consolidated architecture is defined as the current system architecture, the distributed architecture will be discussed further here.

ID: 978

2.3.1.2 Distributed Architecture Definitions

ID: 979

The number of operational satellites under normal conditions for the distributed architectures is four, although the satellites are not as large. The constellation will consist of an A satellite and a B satellite in the East location and an A satellite and a B satellite in the West location. If P^3I requirements are met, potentially more than four satellites and nominally called the C satellites will be present in the distributed architecture.

ID: 980

The East and West locations are nominally 75 and 135 degrees longitude respectively. The nominally 137-degree position is being investigated as a replacement for the 135-degree position due to a possible conflict with another satellite.

ID: 981

If the C satellite is implemented as part of P^3I to meet the GPRD-1fd requirement of temperature and moisture sounding under all weather conditions (including through clouds), the C satellite will be located either at the central position of nominally 105 degrees West if there is only one satellite or at each of the East and West positions, which is the desired configuration.

ID: 982

On-orbit spare satellites (see section 2.4.3), will be nominally stored at 105 degrees West.

ID: 983

All satellites will be within +/- 0.5 (TBR) degrees of 0 degrees North. The first A satellite will be launched nominally in 2012. The first B satellite will be launched nominally in 2012. The first C satellite, if implemented as part of P^3I, will be launched in 2015.

ID: 984

Currently, the primary mission of the A satellite is to provide imaging from the Advanced Baseline Imager described further in section 2.10.1. The satellite will also contain the Solar Imaging Suite (SIS) of instruments described further in section 2.10.4. The GOES Lightning Mapper, described in section 2.10.6 will be located on the A satellite. Communication payload services, as detailed in section 2.10.8 and 3, will also be included on the satellite.

ID: 985

Currently, the primary mission of the B satellite is to provide sounding of the disk of the earth as seen from the satellite, mesoscale severe weather sounding and imaging, and multifunction imaging from the HES, described further in section 2.10.2. The satellite will contain the Space Environmental In-Situ Suite (SEISS) and the magnetometer described further in section 2.10.4. Communication payload services, as detailed in sections 2.10.8, and 3, will also be included on the satellite.

ID: 986

Currently, the primary mission of the C satellite(s), if implemented as part of P3I, would be to provide microwave measurements of moisture for GOES to improve retrieval performance in non-clear conditions. The C satellite(s) will contain the Solar Coronagraph instrument, if implemented as part of P^3I, described further under section 2.10.4. Any remaining space in the satellite will be allocated to additional P^3I resources. Communication payload services, as detailed in sections 2.10.8, and 3, may be included on the satellite(s). If implemented as part of P^3I, it is currently envisioned that there will be a single C satellite located nominally at 105 degrees West. If two C satellites are used, then it is likely that the C satellites will join the A and B satellites at both 75 degrees West and 135 degrees West.

ID: 987

Currently it is assumed that the A, B, and C satellites employ a common design due to the associated cost savings from reducing non-recurring engineering.

ID: 988

Discussion: To the extent valid, this will be studied in detail during satellite formulation.

ID: 989

2.3.2 Constellation Restrictions and Requirements

ID: 990

The location of each satellite in the constellations must be controllable by NOAA ground systems to within +/-0.5 degrees in latitude and longitude.

ID: 6350

Discussion: The space segment availability over the system lifetime under various scenarios is shown in the table below. The lowest operational availability, 0.81, occurs when there is only one of one of the primary instruments operating in a back-up mode.

ID: 991

2.3.3 Constellation Failure

ID: 992

A constellation failure is experienced when there is no back-up available whatsoever for a satellite that has a failure. A constellation failure does not occur upon the failure of one satellite if it can be replaced with another satellite of a different type operating in a backup mode. Planned reduced constellation performance will result, which is deemed acceptable by NOAA. A satellite failure may be caused by a hardware or software failure on the satellite that prevents the satellite from fulfilling its mission. A satellite may be deemed a failure as a result of a primary instrument failure, described in section 2.4.3, or a communications failure that does not permit the primary instruments to downlink their sensor data.

ID: 993

2.3.4 Constellation Transition Strategy

ID: 994

The constellation will be formed as the result of the launch(es) of an A and a B satellite. It is assumed that 6 to 12 months later, another A satellite and another B satellite will be launched. After a period nominally equivalent to the mean mission duration, there will be another launch(es) of an A satellite and a B satellite. After 6 to 12 months, the next A and B satellites will be launched to provide a full replacement of the constellation. Satellite replacement is discussed in section 2.4.3.

ID: 995

2.3.5 Constellation Success

ID: 996

Final constellation success is achieved when both A satellites, both B satellites, and possibly both C satellites (if available) are located in their nominal positions and have successfully completed checkout/commissioning and meets the seven-year operational lifetime after instrument activation.

ID: 997

2.4 SATELLITES

ID: 998

2.4.1 Satellite Lifetime

ID: 999

The satellite (bus plus instruments) shall be designed for an 8.25 year Mean Mission Duration (MMD) after 10 years. The MMD is the integrated area under the instrument reliability versus time curve. MMD applies after all storage (ground and on-orbit) and after launch discussed in section 2.4.3. This operational requirement shall be met after 5 years of ground storage and 5 years on on-orbit storage. The on-orbit storage degradation for the satellites (bus plus instruments) is TBD and must be included to meet the MMD specification.

Discussion: This means that the satellite, including instruments, will provide 10-year satellite on-life with satellite reliability of 0.54 at end of life for the distributed architecture and TBD for the consolidated architecture. (On-life simply means that the satellite will be operating for a period of 10 years with a reliability of 0.6 at the 10-year point.) This follows the on-orbit storage time and ground storage time discussed in section 2.4.3. As detailed for the HES and ABI, a 10-year instrument-on life shall be supported with Instrument Reliability (R) of 0.6, based on a satellite Reliability of >/= 0.90 at 10 years.

ID: 1000

Blank

ID: 1001

2.4.2 Satellite Failure

ID: 1002

Replacement of the satellite with a spare will be necessary when one of the primary instruments, namely ABI or HES fails to meet the specified noise performance required to produce its primary products. The instrument noise increase is a factor of (TBD). All conditions that produce no signal or permit no data transmission on the sensor data downlink and consequently yield indeterminate instrument noise performance also constitute a failure. NOAA will decide if the level of performance for a given instrument is sufficient to continue operation of any satellite beyond the specified lifetime.

ID: 1003

2.4.3 Satellite Replacement Strategy

ID: 1004

The distributed satellite approach differs from the previous GOES series where a failure of one primary instrument (imager or sounder, or for GOES-R, ABI or HES) led to the replacement of the entire satellite. The distributed satellite approach permits the replacement of an A or B satellite optimally with another A or B satellite. To prevent a mission failure, either a spare satellite may be moved into place to provide the needed coverage or an existing operational satellite may be repositioned to provide the needed coverage. The replacement strategy will provide a replacement A or B satellite on schedule for a seven-year operation life. If the A or B satellite fails with no on-orbit spare this may result in a period of degraded performance until a replacement satellite is launched.

ID: 1005

Discussion: However, due to the need for ABI data, the failure of satellite A will result in a repositioning of the functioning A satellite to the nominal 105-degree West position. The remaining B satellites in the East and West positions will take over some of the imaging task of the A satellites. The HES instrument in the B satellite must be capable of yielding image data at reduced spectral resolution to permit a backup of the ABI capabilities. The failure of a B satellite will result in a repositioning of the operating B satellite to the nominal 105-degree West position because the B satellite cannot be easily backed up with another type of satellite. For either a distributed or a consolidated architecture, the repositioning shall be by manual authorization. For either a distributed or a consolidated architecture, the repositioning shall be completed in drift rate of 1 degree per day (THRESHOLD) and a drift rate of 10 degrees per day (GOAL).

ID: 1006

Satellite Design

ID: 1007

The satellite shall meet, in conjunction with the related instruments error(s), the product requirement for pointing and mapping as defined for each instrument under section 2.10.

ID: 1008

2.5 DESCRIPTION OF SPACECRAFT REQUIREMENTS

ID: 1009

The terms spacecraft here applies to the platforms that will contain the instrument payloads and the communications services payloads.

ID: 1010

2.5.1 General Requirements

ID: 1011

Each spacecraft in the GOES-R constellation shall accommodate the appropriate instrument payload for the satellite, as defined in section 2.3.1. The instrument payload accommodation will include allocations, at a minimum, for the mass, power, size, data rate, pointing control and knowledge, and FOVs.

ID: 1012

The spacecraft shall be capable of operating all the following simultaneously and continuously, including during eclipse: spacecraft subsystems, communication payload services, and instrument payloads in their normal operational modes.

ID: 1013

The spacecraft shall be a 3-axis stabilized, nadir pointing design.

ID: 1014

The spacecraft shall be capable of autonomously maintaining on board timing consistent with the ground system.

ID: 1015

The spacecraft shall provide electrical power, power management, power distribution, energy storage, load shedding, and protection against over voltage, and over current, for all modes.

ID: 1016

The spacecraft structure shall be of sufficient strength and stiffness to maintain structural integrity and withstand all ground testing, handling, transportation, launch, and mission orbit environments.

ID: 1017

The spacecraft thermal control design shall maintain all spacecraft subsystems and components, and instrument interfaces at required temperature levels, holding any required thermal gradients, and maintaining temperature stability during all time-varying temperature changes over the mission lifetime for all satellite operations and orientations.

ID: 1018

The spacecraft shall provide a telemetry and command system to allow spacecraft stored and real-time control, tasking, software uploads, health and status verifications, command verifications, and anomaly resolution.

ID: 1019

The spacecraft communications described in this space-located segment shall be sized to down link the mission payload data with TBD margin.

ID: 1020

The spacecraft shall be capable of maintaining spacecraft and instrument health and safety margins without ground intervention.

ID: 1021

The spacecraft shall have a fault detection and correction system.

ID: 1022

The spacecraft shall have an autonomous operation capability of supporting all routine science operations with no more than TBD minutes of command uplink contact every TBD hours.

ID: 1023

2.5.2 Safe Hold Mode

ID: 1024

The spacecraft shall have a Safe Hold mode that protects the satellite from catastrophic failures and provides a means to return to normal operations.

ID: 1025

2.5.3 Launch vehicle

ID: 1026

The nominal launch vehicle (LV), for nominal distributed architecture baseline, shall be an Evolved Expendable Launch Vehicle - Medium (EELV-M) class vehicle capable of co-manifesting two (A, B, or C) satellites per launch.

ID: 1027

The LV shall meet the Buy America Act.

ID: 1028

The launch site shall be located at Cape Canaveral Air Station (CCAS), Florida.

ID: 1029

The LV shall have a demonstrated flight record of reliability with a Ps of TBD or better.

ID: 1030

The LV shall not hinder the spacecraft in achieving the required final orbit.

ID: 1031

2.6 NOAA MISSION CRITICAL MEASUREMENTS

ID: 1032

2.6.1 Pre-launch Calibration

ID: 1033

The science payload shall be calibrated prior to launch as required to meet the instrument performance requirement specified for each instrument under section 2.10.

All absolute measurements should be in the SI system of units and have reported uncertainties. All claims of traceability regarding these measurements shall be documented. The government will review and assess the validity of the traceability claims pertaining to radiometry.

ID: 1034

2.7 SATELLITE LAUNCH SERVICES

ID: 1035

2.7.1 Pre-launch Activities

ID: 1036

The Launch Site Services (LSS) shall have the capability to perform the required pre-launch test and operations necessary, and to successfully launch the GOES-R Series Satellites.

ID: 1037

The LSS shall provide a payload processing facility for conducting all non-hazardous and hazardous satellite operations.

ID: 1038

The LSS shall have the capability to command and monitor the health and status of the satellite all pre-launch and launch operations.

ID: 1039

The LSS shall provide LV telemetry during all portions of the LV powered flight and during Satellite separation.

ID: 1040

The satellite shall provide telemetry and be configured to receive commands during the entire launch, transfer orbit, and orbit raising to geosynchronous.

ID: 1041

2.7.2 Transmission to Deep Space Network (DSN) Or Similar System during Launch and Orbit Raising (LOR)

ID: 1042

During the launch, transfer orbit and orbit raising phase, satellite to ground communications and transmissions shall go through the DSN or a similar ground network.

ID: 1043

During satellite deployments, motor burns and other critical operations, a primary and backup ground station shall be identified.

ID: 1044

2.7.3 Measurements from Space Weather Instruments during LOR

ID: 1045

To help determine the surrounding satellite environment during orbit raising phase, certain SEISS instruments may be operational. SEISS instrument resources must be provided during this phase.

ID: 1046

2.8 SATELLITE POST-LAUNCH TEST PHASE (PLT)

ID: 1047

Post-launch satellite and instrument on-orbit validation of performance shall be accomplished.

ID: 1048

2.8.1 On-orbit acceptance of each instrument

ID: 1049

TBD

ID: 1050

2.8.2 On-orbit acceptance of each satellite

ID: 1051

TBD

ID: 6310

2.8.3 Instrument activation after storage

ID: 6311

After storage and at the earliest safe date, the visible detectors of the science payloads shall be activated. After a period of outgassing and cooling spanning several days, the IR detector of the science payloads shall be activated at the earliest safe date.

ID: 1052

2.9 REMOVED

ID: 1053

2.10 PAYLOADS

ID: 1054

2.10.1 ABI (Advanced Baseline Imager)

ID: 1056

(2.10.1) 1. Requirements Overview

ID: 1057

This is NOAA's statement of performance characteristics for an operational advanced imaging instrument drawn from the former GORD-I (December 2002), the new GPRD-1fd (July 2003 and January, 2004), and the National Weather Service (NWS) Operational Requirements Document (ORD), January 1999; from the results of Phase-A instrument concept studies and Phase-B formulation studies; from scientific technical and cost trade analyses; as well as NOAA-NESDIS's assessment of future NOAA GOES needs. The requirements represent NOAA's advanced baseline for geostationary imaging performance, and thus the notional instrument they define is termed the Advanced Baseline Imager (ABI). The formulation phase was completed in December 2003.

ID: 1058

NOAA assumes that the ABI is distinct from an atmospheric sounding instrument. Spacecraft-specific and ground-processing requirements are excluded wherever possible. However, certain design goals for the ABI, described in Section 2, as well as specific performance characteristics described in Section 3, may result in the inclusion of a ground-processing segment as part of the overall "imager system."

ID: 1059

The final requirements set in this portion of the MRD lie between the threshold and goal values set by the GPRD-1. The requirements in this version of the document form the basis for a NASA procured imager for NOAA are those judged to reflect a balance between NOAA needs, technical and scientific tradeoffs instrument complexity, costs, technology availability, and system (imager and spacecraft) impacts.

ID: 1060

(2.10.1) 2. Design Goals for the Advanced Baseline Imager

ID: 1061

NOAA anticipates that the first ABI will be available for flight on GOES-R, with a projected launch date of 2012. Mass, power, and volume for ABI are not being constrained to that of the imager on the N-Q satellite bus. The form of the satellite is unknown at this point in time (see section 2.3.1.) Initially, NOAA used the environmental parameters (mass; power; volume) of the current series of GOES instruments as target limits for concept studies to identify notional imager characteristics; NOAA's intent was to allow potential imager designs to surface that would minimize engineering and cost impacts. Formulation studies now completed have identified each vendor's suggested instrument design. Final numbers are identified in the Unique Instrument Interface Document (UIID) and the General Instrument Requirements Document (GIRD) .

ID: 1062

Specific requirements related to the spacecraft interface are given in Section 3.C.8.

ID: 1063

(2.10.1) 3. Performance Characteristics

ID: 1064

Requirements listed in this section result from technical analyses performed by NOAA and are contained in the GPRD-1fd, which frames the rationale for most ABI performance characteristics. Each technical requirement given below is numbered in order of its appearance in the NWS ORD. Additional requirements that are derived from technical concept studies and trade analyses are subsequently listed.

ID: 1065

A two-level definition is used for NOAA's validated requirements:

ID: 1066

THRESHOLD: The minimum acceptable performance characteristic.

ID: 1067

GOAL: An optimum level of performance, which, if met, could greatly enhance data utility.

ID: 1068

The following GPRD-1fd requirements will be met/addressed by ABI. (See section 2.11.3 for relevant comments.) It is critical to note that this information is included here is for reference only and provides traceability to the GPRD-1fd. The detailed requirements for the ABI are detailed in subsections *after* this section. (See section 2.11.3 for relevant comments.) All parameters listed here are threshold values and may be exceeded to meet goal values. Goal values are currently listed in Appendix A.

ID: 1069

For reference, the distinction between "measure" and "Contribute to determinations of" indicates whether the GPRD-1fd requirement is being fully met by a direct measurement performed by the instruments ("measure") or is being determined indirectly from measurements supplied in part or in whole by the instruments ("Contribute to determinations of").

ID: 1070

ABI will *contribute to* determinations of **Aerosol Particle Size** in the atmosphere. ABI will report a total column value over the full disk to meet the following details of the threshold requirement for the Aerosol Particle Size: 2 km spatial resolution, 15 minute refresh rate, 1.0 km mapping accuracy, and 5 minute data latency need.

ID: 1071

ABI will *contribute to* determinations of **Aerosol Detection--CONUS (including smoke and dusk)** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Aerosol Detection--CONUS (including smoke and dusk): 2 km spatial resolution, over the total column vertically, over the range of yes/no detection with an accuracy of (TBS), 15 minute refresh rate, 1.0 km mapping accuracy, and 15 minute data latency need.

ID: 1072

ABI will *contribute to* determinations of **Aerosol Detection--Hemispheric (including smoke and dusk)** in the atmosphere. ABI provides coverage over the full disk to attempt to meet the following details of the threshold requirement for the Aerosol Detection--Hemispheric (including smoke and dusk): 2 km spatial resolution, over the total column vertically , over the range of yes/no detection with an accuracy of (TBS), 15 minute refresh rate, 1.0 km mapping accuracy, and 3 minute data latency need.

ID: 1073

ABI will *contribute to* determinations of **Aerosol Detection--Mesoscale (including smoke and dusk)** in the atmosphere. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Aerosol Detection--Mesoscale (including smoke and dusk): 2 km spatial resolution, over the total column vertically, over the range of yes/no detection with an accuracy of (TBS), 15 minute refresh rate, 1.0 km mapping accuracy, and 15 minute data latency need.

ID: 1074

ABI will *contribute to* determinations of **Dust/Aerosol Loading--CONUS** in the atmosphere. ABI provides coverage over the CONUS to attempt to meet the following details of the threshold requirement for the Dust/Aerosol Loading--CONUS: 10 km spatial resolution, 15 minute refresh rate, 5.0 km mapping accuracy, with a measurement range of "light, moderate, heavy", and 3 minute data latency need.

ID: 1075

ABI will *contribute to* determinations of **Suspended Matter--CONUS** in the atmosphere. ABI provides total column coverage over the CONUS to meet the following details of the threshold requirement for the Aerosol Detection--CONUS: 2 km spatial resolution, over the total column vertically, with a measurement range of (TBS) and a measurement accuracy of (TBS), 5 minute refresh rate, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1076

ABI will *contribute to* determinations of **Suspended Matter: Hemispheric** in the atmosphere. ABI provides total column coverage over the full disk to meet the following details of the threshold requirement for the Suspended Matter-Hemispheric: 2 km spatial resolution, over the total column vertically, with a measurement range of (TBS) and a measurement accuracy of (TBS), 15 minute refresh rate, 1.0 km mapping accuracy, and 3 minute data latency need.

ID: 1077

ABI will *contribute to* determinations of **Volcanic Ash--Detection and Height** in the atmosphere. ABI provides coverage over the full disk to attempt to meet the following details of the threshold requirement for the Volcanic Ash: 2 km spatial resolution, 15 minute refresh rate, 2 km vertical resolution on top height, a measurement range of 0-50 metric tons/km^2 with an accuracy of (TBS), 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1078

ABI will *measure* **Cloud Imagery: Coastal** in the atmosphere. ABI provides coverage over the US Navigable waterways through the Exclusive Economic Zone to meet the following details of the threshold requirement for the Cloud Imagery: Coastal: 1 km (day) and 2 km (night) spatial resolution, 180 minute refresh rate, < or = 1.0 km mapping accuracy, and 15 minute data latency need.

ID: 1079

ABI will *measure* **Cloud and Moisture Imagery--CONUS** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Cloud and Moisture Imagery--CONUS: 2 km spatial resolution, 5 minute refresh rate, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1080

ABI will *measure* **Cloud and Moisture Imagery: Hemispheric** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Cloud and Moisture Imagery: Hemispheric: 2 km spatial resolution, 5 minute refresh rate, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1081

ABI will *measure* **Cloud and Moisture Imagery--Mesoscale** in the atmosphere. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Cloud and Moisture Imagery--Mesoscale: 2 km spatial resolution, 30 second refresh rate, 1.0 km mapping accuracy, and 30 second data latency need.

ID: 1082

ABI will *contribute to* determinations of **Cloud Ice Water Path--CONUS (limited cloudiness)** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Cloud Ice Water Path--CONUS (limited cloudiness): 2 km spatial resolution, 5 minute refresh rate, a vertical range covering the surface to 20 km, with a measurements range of 0-2 mm and a measurement accuracy that is the greater of 0.1 mm or 25% (day) and is achievable for only the thinnest clouds (night), 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1083

ABI will *contribute to* determinations of **Cloud Ice Water Path: Hemispheric (limited cloudiness)** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Cloud Ice Water Path: Hemispheric (limited cloudiness): 2 km spatial resolution, 15 minute refresh rate, a vertical range covering the surface to 20 km, with a measurements range of 0-2 mm and a measurement accuracy that is the greater of 0.1 mm or 25% (day) and is achievable for only the thinnest clouds (night) that is the greater of 0.1 mm or 25%, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1084

ABI will *contribute to* determinations of **Cloud Ice Water Path--Mesoscale (limited cloudiness)** in the atmosphere. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Cloud Ice Water Path: Mesoscale (limited cloudiness): 2 km spatial resolution, 1 minute refresh rate, a vertical range covering the surface to 20 km, with a measurements range of 0-2 mm and a measurement accuracy achievable for only the thinnest clouds in the day that is the greater of 0.1 mm or 25% and at night < 50%, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1085

ABI will *contribute to* determinations of **Cloud Layer/Heights and Thickness--CONUS** in the atmosphere with HES. ABI provides multiple cloud layer imagery coverage over the CONUS at least every 15 minutes, and with a 15 minute data latency that will facilitate this product that is measured more slowly over the CONUS by the HES-DS.

ID: 1086

ABI will *contribute to* determinations of **Cloud Layer/Heights and Thickness--Hemisphere** in the atmosphere with HES. ABI provides multiple cloud layer imagery coverage over the Hemisphere at least every 60 minutes and with a 15 minute data latency, which will facilitate this product.

ID: 1087

ABI will *contribute to* determinations of **Cloud Layer/Heights and Thickness--Mesoscale** in the atmosphere with HES. ABI provides multiple cloud layer imagery coverage over the mesoscale at least every 15 minutes, which will facilitate this product.

ID: 1088

ABI will *contribute to* determinations of **Cloud Liquid Water--CONUS** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Cloud Liquid Water--CONUS: 2 km spatial resolution, 30 minute refresh rate, a vertical range covering the total column, with a measurements range of 0-2 mm and a measurement accuracy that is the greater of 0.1 mm or 25% (day) and is achievable for only the thinnest clouds (night), 1.0 km mapping accuracy, and 15 minute data latency need.

ID: 1089

ABI will *contribute to* **Cloud Liquid Water: Hemispheric** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Cloud Liquid Water: Hemispheric (limited cloudiness): 2 km spatial resolution, 30 minute refresh rate, a vertical range covering the total column, with a measurements range of 0-2 mm and a measurement accuracy that is the greater of 0.1 mm or 25% (day) and is achievable for only the thinnest clouds (night) that is the greater of 0.1 mm or 25%, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1090

ABI will *contribute to* determinations of **Cloud Liquid Water--Mesoscale** in the atmosphere. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Cloud Liquid Water--Mesoscale: 2 km spatial resolution, 1 minute refresh rate, a vertical range covering the surface to 20 km, with a measurements range of 0-2 mm and a measurement accuracy achievable for only the thinnest clouds in the day that is the greater of 0.1 mm or 25% and at night < 50%, 1.0 km mapping accuracy, and 15 minute data latency need.

ID: 1091

ABI will *contribute to* determinations of **Cloud Optical Depth--CONUS** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Cloud Optical Depth--CONUS: cloud optical depth values of > 1, 2 km spatial resolution, 30 minute refresh rate, with a measurement range of 0-100 (in O.D. units) and a measurement accuracy of 10%, 1.0 km mapping accuracy, and 15 minute data latency need.

ID: 1092

ABI will *contribute to* determinations of **Cloud Optical Depth--Hemisphere** in the atmosphere. ABI provides coverage over the Hemisphere to meet the following details of the threshold requirement for the Cloud Optical Depth--Hemisphere: cloud optical depth values of > 1, 4 km spatial resolution, 15 minute refresh rate, with a measurement range of 0.5-50 (in O.D. units) and a measurement accuracy of 10%, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 5836

ABI will *contribute to* determinations of **Cloud Particle Size Distribution -- CONUS** in the atmosphere. ABI provides total column and observation height measurements. ABI will have coverage over the full disk to meet the following details of the threshold requirement for the Cloud Particle Size Distribution--CONUS: 2 km spatial resolution, 5 minute refresh rate, a vertical range of at the cloud top height, with a measurements range of 0-50 um with a measurement accuracy of 4 um, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1093

ABI will *contribute to* determinations of **Cloud Particle Size Distribution: Hemispheric** in the atmosphere. ABI provides total column and observation height measurements. ABI will have coverage over the full disk to meet the following details of the threshold requirement for the Cloud Particle Size Distribution--Hemisphere: 2 km spatial resolution, 15 minute refresh rate, a vertical range of at the cloud top height, with a measurements range of 0-50 um with a measurement accuracy of 4 um, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1094

ABI will *contribute to* determinations of **Cloud Particle Size Distribution--Mesoscale** in the atmosphere. ABI provides total column coverage over the mesoscale to meet the following details of the threshold requirement for the Cloud Particle Size Distribution--Mesoscale: 2 km spatial resolution, 5 minute refresh rate, a vertical range of at cloud height, with a measurement range of 0-50 um with a measurement accuracy of 4 um, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1095

ABI will *contribute to* determinations of **Cloud Phase--CONUS** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Cloud Top Phase--CONUS: 2 km spatial resolution, 5 minute refresh rate, vertical resolution of at the cloud top, measurement range of liquid/solid/supercooled/mixed, measurement accuracy of TBS, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1096

ABI will *contribute to* determinations of **Cloud Top Phase: Hemispheric** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Cloud Top Phase: Hemispheric: 2 km spatial resolution, 15 minute refresh rate, vertical resolution of at the cloud top, with a measurement range of liquid/solid/supercooled/mixed, measurement accuracy of (TBS), 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1097

ABI will *contribute to* determinations of **Cloud Top Phase--Mesoscale** in the atmosphere. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Cloud Top Phase--Mesoscale: 2 km spatial resolution, 1 minute refresh rate, vertical resolution of at the cloud top, with a measurements range of liquid/solid/supercooled/mixed with a measurement accuracy of (TBS), 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1098

ABI will *contribute to* determinations of **Cloud Top Height--CONUS** in the atmosphere, although HES-DS will produce the vertical resolution for the cloud top height.

ID: 1099

ABI will *contribute to* determinations of **Cloud Top Height: Hemispheric** in the atmosphere, although HES-DS will produce the vertical resolution for the cloud top height.

ID: 1100

ABI will *contribute to* determinations of **Cloud Top Height--Mesoscale** in the atmosphere, although HES-SW/M will produce the vertical resolution for the cloud top height.

ID: 1101

ABI will *contribute to* determinations of **Cloud Top Pressure--CONUS** in the atmosphere (by contributing to cloud top height), although HES-DS will produce the vertical resolution for the Cloud Top Pressure.

ID: 1102

ABI will *contribute to* determinations of **Cloud Top Pressure: Hemispheric** in the atmosphere (by contributing to cloud top height), although HES-DS will produce the vertical resolution for the Cloud Top Pressure.

ID: 1103

ABI will *contribute to* determinations of **Cloud Top Pressure--Mesoscale** in the atmosphere (by contributing to cloud top height), although HES-SW/M will produce the vertical resolution for the Cloud Top Pressure.

ID: 1104

ABI will *contribute to* determinations of **Cloud Top Temperature: Hemispheric** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Cloud Top Temperature--Hemisphere: at cloud top; 2 km spatial resolution, 15 minute refresh rate, with a measurement range of 180 to 300 K with 1 K measurement accuracy, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1105

ABI will *contribute to* determinations of **Cloud Top Temperature--Mesoscale** in the atmosphere. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Cloud Top Temperature--Mesoscale: at cloud top; 2 km spatial resolution, 1 minute refresh rate, with a measurement range of 190 to 300 K with 0.5 K measurement accuracy, 1.0 km mapping accuracy, and 5 minute data latency need.

ID: 1106

ABI will *contribute to* determinations of **Cloud Type--CONUS** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Cloud Type--CONUS: 10 km spatial resolution, 30 minute refresh rate, with a measurement range of 7 types, (TBS) mapping accuracy, and 10 minute data latency need.

ID: 1107

ABI will *contribute to* determinations of **Cloud Type--Hemispheric** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Cloud Type: Hemispheric: 10 km spatial resolution, 15 minute refresh rate, with a measurement range of 7 types, (TBS) mapping accuracy, and 1 minute data latency need.

ID: 1108

ABI will *contribute to* determinations of **Cloud Type--Mesoscale** in the atmosphere. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Cloud Type--Mesoscale: 10 km spatial resolution, 15 minute refresh rate, with a measurements range of 7 types, (TBS) km mapping accuracy, and 1 minute data latency need.

ID: 1109

ABI will *contribute to* determinations of **Convective Initiation** in the atmosphere. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Convective Initiation 2 km spatial resolution, 15 minute refresh rate, vertical resolution of (TBS), with a measurement range of (TBS) and a measurement accuracy of (TBS), 1.0 km mapping accuracy, and 3 minute data latency need.

ID: 1110

ABI will *measure* **Enhanced "V" / Overshooting Cloud Top Detection--CONUS** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Enhanced "V" / Overshooting Cloud Top Detection--CONUS: 2 km spatial resolution, 15 minute refresh rate, with a measurement range of 0-1 binary detection (160-270 K) and a measurement accuracy of 10% detection (1.0 K cloud top), 1.0 km mapping accuracy, and 5 minute data latency need.

ID: 1111

ABI will *measure* **Enhanced "V" / Overshooting Cloud Top Detection--Mesoscale** in the atmosphere. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Enhanced "V" / Overshooting Cloud Top Detection--Mesoscale: 2 km spatial resolution, 1 minute refresh rate, with a measurement range of 0-1 binary detection (160-270 K) and a measurement accuracy of 10% detection (1.0 K cloud top), 1.0 km mapping accuracy, and 5 minute data latency need.

ID: 1112

ABI will *contribute to* determinations of **Hurricane Intensity** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Hurricane Intensity: 2 km spatial resolution, 30 minute refresh rate, with (TBS) vertical resolution, a measurement range of (TBS), a measurement accuracy of 5 m/s, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1113

ABI will *measure* **Imagery: All weather- Day/Night** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the clear and above cloud regions only for Imagery: All weather- Day/Night: 2 km spatial resolution, TBS refresh rate, with measurement range of (TBS), measurement accuracy of (TBS), 1.0 km mapping accuracy, and TBS minute data latency need.

ID: 1114

ABI will *measure* **Low Cloud and Fog** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Low Cloud and Fog: 2 km spatial resolution, 30 minute refresh rate, of 0.5 km (depth), with a measurements range Fog/No Fog with 70% detection (30% false alarm), 1.0 km mapping accuracy, and 5 minute data latency need.

ID: 1115

ABI will *contribute to* determinations of **Turbulence: Hemispheric** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Turbulence: Hemispheric: 2 km spatial resolution, 15 minute refresh rate, with a measurement range of binary moderate or greater (over 0.1 km - 4 km) vertically, and a measurement accuracy of N/A, with vertical resolution of Sfc-500 mb: 300-500 m, 500-300 mb: 1-2 km, 300-100 mb: 1-2 km, 100 mb and up: 2-3 km, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1116

ABI will *contribute to* determinations of **Turbulence--Mesoscale** in the atmosphere. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Turbulence--Mesoscale: 2 km spatial resolution, 1 minute refresh rate, with a measurement range of binary moderate or greater (over 0.1 km - 4 km) vertically, and a measurement accuracy of N/A, with vertical resolution of Sfc-500 mb: 300-500 m, 500-300 mb: 1-2 km, 300-100 mb: 1-2 km, 100 mb and up: 2-3 km, 1.0 km mapping accuracy, and 5 minute data latency need.

ID: 1117

ABI will *contribute to* determinations of **Visibility: Coastal** in the atmosphere. ABI provides coverage over the US Navigable waterways through the Exclusive Economic Zone to meet the following details of the threshold requirement for the Visibility: Coastal: meeting 3 km spatial resolution, 3 hour refresh rate, vertical resolution of TBS, with a measurement range of 0-3.2 km and a measurement accuracy of (TBS), contributing 1.0 km mapping accuracy, and 15 minute data latency need.

ID: 1118

ABI will *measure* **Visibility: Hemispheric** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Visibility: Hemispheric: 10 km spatial resolution, 60 minute refresh rate, with a vertical resolution of (TBS), with a measurement range of 0-30 km and a measurement accuracy of (TBS) over 0-15 km and (TBS) over 15-60 km, and 15 minute data latency need

ID: 1119

ABI will *measure* **Probability of Rainfall** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Probability of Rainfall: 2 km spatial resolution, 15 minute refresh rate, TBS (depth), with a measurements range of 0-100% with 25% measurement accuracy, 1.0 km mapping accuracy, and 5 minute data latency need.

ID: 1120

ABI will *measure* **Rainfall Potential** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Rainfall Potential: 2 km spatial resolution, 15 minute refresh rate, TBS (depth), with a measurements range of 0-100 mm/hr with 5 mm/hr measurement accuracy, 1.0 km mapping accuracy, and 5 minute data latency need.

ID: 1121

ABI will *measure* of **Rainfall Potential / Quantitative Precipitation Estimate** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Rainfall Potential / Quantitative Precipitation Estimate: 2 km spatial resolution, 15 minute refresh rate, of TBS (depth), with a measurements range of 0-100 mm/hr with 2 mm/hr measurement accuracy, 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 1122

ABI will *measure* **Derived Stability--CONUS** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Derived Stability--CONUS: 4 km spatial resolution, 30 minute refresh rate, with a measurement range of (TBS) and a measurement accuracy of (TBS), 1.0 km mapping accuracy, and 3 minute data latency need.

ID: 1123

ABI will *measure* **Derived Stability--Mesoscale** in the atmosphere. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Derived Stability--Mesoscale: 2 km spatial resolution, 5 minute refresh rate, with a measurements range of 0-5000 J/kg and a 5-10% accuracy, 1.0 km mapping accuracy, and 15 minute data latency need.

ID: 1124

ABI will *contribute to* determinations in **Moisture Flux--CONUS** in the atmosphere (by contributing wind determinations) although HES-DS will produce the vertical resolution for Moisture Flux.

ID: 1125

ABI will *contribute to* determinations in **Moisture Flux: Hemispheric** in the atmosphere (by contributing wind determination), although HES-DS will produce the vertical resolution for Moisture Flux.

ID: 1126

ABI will *contribute to* determinations in **Moisture Flux--Mesoscale** in the atmosphere (by contributing wind determination), although HES-SW/M will produce the vertical resolution for Moisture Flux.

ID: 1127

ABI will *measure* **Clear Sky Masks--CONUS** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Clear Sky Masks--CONUS: 2 km spatial resolution, 15 minute refresh, 1 km mapping accuracy, over the measurement range of 0-1 with 10% measurement accuracy, and 15 minute latency.

ID: 1128

ABI will *measure* **Clear Sky Masks: Hemispheric** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Clear Sky Masks: Hemispheric: 2 km spatial resolution, 15 minute refresh, 1 km mapping accuracy, over the measurement range of 0-1 with 10% measurement accuracy, and 15 minute latency.

ID: 1129

ABI will *measure* **Clear Sky Masks--Mesoscale** in the atmosphere. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Clear Sky Masks--Mesoscale: 2 km spatial resolution, 1 minute refresh rate, with a measurements range of 0-1 and a 5-10% accuracy, 1.0 km mapping accuracy, and 5 minute data latency need.

ID: 1130

ABI will *contribute to* determinations of **Downward Solar Insolation: Surface / CONUS** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Downward Solar Insolation: Surface / CONUS: 25 km spatial resolution, 60 minute refresh rate, with a measurement range of 0-1500 W/m^2 and measurement accuracy of 20 W/m^2, 2.0 km mapping accuracy, and 60 minute data latency need.

ID: 5844

ABI will *contribute to* determinations of **Absorbed Shortwave Radiation: Surface / Mesoscale** in the atmosphere because a proxy for this product is determined by NOAA from insolation and albedo. The validity of this proxy is beyond the scope of this document. ABI provides coverage over 1000 km x 1000 km to meet the following details of the threshold requirement for the Absorbed Shortwave Radiation: Surface / Mesoscale: 5 km spatial resolution, 60 minute refresh rate, mapping accuracy of (TBS) km, with a measurement range of TBS, a measurement accuracy of (TBS), and 60 minute data latency need.

ID: 5845

ABI will *contribute to* determinations of **Downward Longwave Radiation: Surface / CONUS** in the atmosphere because a proxy for this product is determined by NOAA from the shortwave radiation. The validity of this proxy is beyond the scope of this document. ABI provides coverage over 5000 km x 3000 km to meet the following details of the threshold requirement for the Downward Longwave Radiation: Surface / CONUS: 25 km spatial resolution, 60 minute refresh rate, mapping accuracy of 5 km, with a measurement range of TBS, a measurement accuracy of (TBS), and 60 minute data latency need.

ID: 5846

ABI will *contribute to* determinations of **Downward Longwave Radiation: Surface / Hemispheric** in the atmosphere because a proxy for this product is determined by NOAA from the shortwave radiation. The validity of this proxy is beyond the scope of this document. ABI provides coverage over 5000 km x 3000 km to meet the following details of the threshold requirement for the Downward Longwave Radiation: Surface / Hemispheric 100 km spatial resolution, 360 minute refresh rate, mapping accuracy of (TBS) km, with a measurement range of TBS, a measurement accuracy of (TBS), and 120 hour data latency need.

ID: 5864

ABI will *contribute to* determinations of **Downward Solar Insolation: Surface / CONUS** in the atmosphere.. The validity of this proxy is beyond the scope of this document. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Downward Solar Insolation: Surface / CONUS: 25 km spatial resolution, 60 minute refresh rate, 0-1500 W/m^2 measurement range, (TBS) measurement accuracy, 2 km mapping accuracy, and 60 minute data latency need.

ID: 1131

ABI will *contribute to* determinations of **Downward Solar Insolation: Surface / Hemispheric** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Downward Solar Insolation: Surface / Hemispheric: 50 km spatial resolution, 60 minute refresh rate, 0-1500 W/m^2 measurement range, (TBS) measurement accuracy, (TBS) km mapping accuracy, and 60 minute data latency need.

ID: 1132

ABI will *contribute to* determinations of **Downward Solar Insolation: Surface / Mesoscale** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Downward Solar Insolation: Surface / Mesoscale: 5 km spatial resolution, 60 minute refresh rate, 0-1500 W/m^2 measurement range, (TBS) measurement accuracy, (TBS) km mapping accuracy, and 60 minute data latency need.

ID: 1133

ABI will *contribute to* determinations of **Reflected Solar Insolation: TOA/ CONUS** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Downward Solar Insolation: TOA / CONUS: 25 km spatial resolution, 60 minute refresh rate, with a measurement range of 0-1200 W/m^2 and measurement accuracy of TBS, 2.0 km mapping accuracy, and 60 minute data latency need.

ID: 1134

ABI will *contribute to* determinations of **Reflected Solar Insolation: TOA / Hemispheric** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Reflected Solar Insolation: TOA / Hemispheric: 250 km spatial resolution, 6 hour refresh rate, with measurement range of 0-1200 W/m^2, measurement accuracy of (TBS), (TBS) km mapping accuracy, and 720 hour data latency need.

ID: 1135

ABI will *measure* **Ozone Total--CONUS** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Ozone Total--CONUS: 10 km spatial resolution, 60 minute refresh rate, with a measurement range of 50-650 (DU) and measurement accuracy of 6%, 5 km mapping accuracy, and 5 minute data latency need.

ID: 1136

ABI will *measure* **Ozone Total--Hemisphere** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Ozone Total--Hemispheric: 10 km spatial resolution, 60 minute refresh rate, 5 with a measurement range of 50-650 (DU) and measurement accuracy of TBS, 5 km mapping accuracy, and 5 minute data latency need.

ID: 5838

ABI will *measure* **SO_2 Detection** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for SO_2: 5 km spatial resolution, 60 minute refresh rate, over the total column, with a measurement range of binary yes/no detection above TBS Dobson Units and measurement accuracy of TBS, 1 km mapping accuracy, and 15 minute data latency need.

ID: 1137

ABI will *measure* **Derived Motion Winds--CONUS** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Derived Motion Winds--CONUS: 2 km spatial resolution, 5 minute refresh rate, with a 4 levels vertical range (including low/mid/mid-high, high), with a measurement range of 0-300 kts and measurement accuracy of TBS, 1 km mapping accuracy, and 3 minute data latency need.

ID: 1138

ABI will *measure* **Derived Motion Winds--Hemisphere** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Derived Motion Winds--Hemispheric: 2 km spatial resolution, 5 minute refresh rate, with a 4 levels vertical range (including low/mid/mid-high, high), with a measurement range of 0-300 knots and measurement accuracy of TBS, 1 km mapping accuracy, and 3 minute data latency need.

ID: 1139

ABI will *measure* **Derived Motion Winds--Mesoscale** in the atmosphere. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Derived Motion Winds--Mesoscale: 2 km spatial resolution, 5 minute refresh rate, with a 4 levels vertical range including low/mid/mid-high, high), with a measurement range of 0-300 kts and measurement accuracy of (TBS), 1 km mapping accuracy, and 3 minute data latency need.

ID: 1140

ABI will *contribute to* determinations of **Microburst Windspeed Potential** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the **Microburst Windspeed Potential**: 10 km spatial resolution, 60 minute refresh rate, 5 km mapping accuracy, and 3 minute data latency need.

ID: 1141

ABI will *measure* **Fire / Hot Spot Imagery--CONUS** on the land. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Fire / Hot Spot Imagery--CONUS: 2 km spatial resolution, 5 minute refresh rate, with a measurement range of 275-400 K and measurement accuracy of 2 K, 1 km mapping accuracy, and 5 minute data latency need.

ID: 1142

ABI will *measure* **Fire / Hot Spot Imagery--Hemisphere** on the land. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Fire / Hot Spot Imagery--Hemispheric: 2 km spatial resolution, 15 minute refresh rate, with a measurement range of 275-400 K and measurement accuracy of 2 K, 1 km mapping accuracy, and 5 minute data latency need.

ID: 1143

ABI will *contribute to* determinations of **Flood Standing Water--Hemisphere** on the land. ABI provides coverage over the full disk to attempt to meet the following details of the threshold requirement for the Flood Standing Water: Hemispheric: 10 km spatial resolution, 60 minute refresh rate, with requested 5 cm vertical resolution, with a measurement range of 0-100% of a pixel, 5 km mapping accuracy, and 6 hour data latency need.

ID: 1144

ABI will *contribute to* determinations of **Flood Standing Water--Mesoscale** on the land. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Flood Standing Water--Mesoscale: 10 km spatial resolution, 60 minute refresh rate, with requested 5 cm vertical resolution, with a measurement range of 0-100% of a pixel, 5 km mapping accuracy, and 6 hour data latency need.

ID: 1145

ABI will *contribute to* determinations of **Ice cover /Landlocked** on the land. ABI provides coverage over the full disk to attempt to meet the following details of the threshold requirements (TBS) and the goal requirements for the Ice cover /Landlocked: (TBS) km spatial resolution, (TBS) hour refresh rate, with a measurement range of TBS of a pixel, with (TBS) km mapping accuracy, and (TBS) minute data latency need.

ID: 1146

ABI will *measure* **Land Surface (Skin) Temperature--CONUS** on the land. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Land Surface (Skin) Temperature--CONUS: 2 km spatial resolution, 60 minute refresh rate, with a measurement range of 233-333 K and measurement accuracy of 1.0 K, 1 km mapping accuracy, and 60 minute data latency need.

ID: 1147

ABI will *measure* **Land Surface (Skin) Temperature--Hemisphere** on the land. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Land Surface (Skin)

Temperature--Hemispheric: 2 km spatial resolution, 60 minute refresh rate, with a measurement range of 233-333 K and measurement accuracy of 1 K, 1 km mapping accuracy, and 3 minute data latency need.

ID: 1148

ABI will *measure* **Land Surface (Skin) Temperature--Mesoscale** on the land. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Land Surface (Skin) Temperature--Mesoscale: 2 km spatial resolution, 60 minute refresh rate, with a measurement range of 213-333 K and measurement accuracy of 1.0 K, 1 km mapping accuracy, and 3 minute data latency need.

ID: 1150

ABI will *contribute to* determinations of **Snow Cover--CONUS** on the land. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Snow Cover--CONUS: 2 km spatial resolution, 60 minute refresh rate, with a measurement range of binary (yes/no) and measurement accuracy yes/no detection, 1 km mapping accuracy, and 60 minute data latency need.

ID: 1151

ABI will *contribute to* determinations of **Snow Cover--Hemisphere** on the land. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Snow Cover--Hemispheric: 2 km spatial resolution, 60 minute refresh rate, with a measurement range of binary (yes/no) and measurement accuracy yes/no detection, 1 km mapping accuracy, and 60 minute data latency need.

ID: 1152

ABI will *contribute to* determinations of **Snow Cover--Mesoscale** on the land. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Snow Cover--Mesoscale: 2 km spatial resolution, 60 minute refresh rate, with a measurement range of binary (yes/no) and measurement accuracy of yes/no detection, 1 km mapping accuracy, and 60 minute data latency need.

ID: 1153

ABI will *contribute to* determinations of **Snow Depth-Plains only--CONUS** on the land. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Snow Depth-Plains only--CONUS: 2 km spatial resolution, 60 minute refresh rate, with a measurement range of 0-10 m and measurement accuracy of (TBS), 1 km mapping accuracy, and 60 minute data latency need.

ID: 1154

ABI will *contribute to* determinations of **Snow Depth-Plains only--Hemisphere** on the land. ABI provides coverage over the full disk to meet the following details of the threshold requirement for the Snow Depth-Plains only: Hemispheric: 2 km spatial resolution, 60 minute refresh rate, with a measurement range of 0-10 m and measurement accuracy of (TBS), 1 km mapping accuracy, and 60 minute data latency need.

ID: 1155

ABI will *contribute to* determinations of **Snow Depth-Plains only--Mesoscale** on the land. ABI provides coverage over the mesoscale to meet the following details of the threshold requirement for the Snow Depth-Plains only--Mesoscale: 2 km spatial resolution, (TBS) refresh rate, with a measurement range of 1-10m and measurement accuracy of (TBS), 1 km mapping accuracy, and (TBS) data latency need.

ID: 1156

ABI will *contribute to* determinations of **Surface Albedo--Hemisphere** on the land. ABI provides coverage over the full disk to attempt to meet the following details of the goal requirement for the Surface Albedo: Hemispheric: 0.5 km spatial resolution, (TBS) refresh rate, with a measurement range of 0-1 albedo units a measurement accuracy of 5%, 1 km mapping accuracy, and (TBS) data latency need.

ID: 1157

ABI will *contribute to* determinations of **Surface Emissivity--CONUS** on the land. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Surface Emissivity: CONUS: 10 km spatial resolution, 60 minute refresh rate, with a measurement range of 0.85-1.0 albedo units and measurement accuracy of 0.05 albedo units, 5 km mapping accuracy, and 60 minute data latency need.

ID: 1158

ABI will *contribute to* determinations of **Vegetation Fraction-Green** on the land. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Vegetation Fraction--Green: 2 km spatial resolution, 60 minute refresh rate, with a measurement range of 0-1 and measurement accuracy of 0.05, 1 km mapping accuracy, and 60 minute data latency need.

ID: 1159

ABI will *contribute to* determinations of **Vegetation Index--CONUS** on the land. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the Vegetation Index---CONUS: 2 km spatial resolution, 60 minute refresh rate, with a measurement range of 0-1 NDVI units and measurement accuracy of 0.04 NDVI units, 1 km mapping accuracy, and 60 minute data latency need.

ID: 1161

ABI will contribute to determinations of the **Currents-Hemispheric** to address the following details of the threshold requirement for the Currents---Hemisphere over the full disk; with a threshold 6 hours refresh; with a 60 minute threshold latency; at 2 km threshold resolution by using the radiance values; using 1.0 km threshold mapping uncertainty; over the range of 0 – 5 m/sec (0 – 18 km/hour); and with 1.0 km/hour accuracy.

ID: 1162

ABI will contribute to determinations of the **Currents--Mesoscale** to address the following details of the threshold requirement for the Currents--Mesoscale over the 1000 km x 400 km; with a threshold 6 hours refresh; with a 60 minute threshold latency; at 2 km threshold resolution by using the radiance values; using 1.0 km threshold mapping uncertainty; over the range of 0 – 5 m/sec (0 – 18 km/hour); and with 1.0 km/hour accuracy.

ID: 1163

ABI will contribute to determinations of the **Currents---"Offshore"/CONUS** to address the following details of the threshold requirement for the Currents---"Offshore"/CONUS over the CONUS EEZ; with a threshold 6 hours refresh; with a 180 minute threshold latency; at 2 km threshold resolution by using the radiance values; using 1.0 km threshold mapping uncertainty; over the range of 0-1.8 km/hour; and with 1.0 km/hour accuracy, and 60 minute latency.

ID: 1164

ABI will contribute to determinations of the **Currents--Hemispheric** to address the following details of the threshold requirement for the Currents--Hemisphere over the full disk; with a threshold (TBS) minute refresh; with a (TBS) minute threshold latency; at TBS km threshold resolution by using the radiance values; using (TBS) km threshold mapping uncertainty; and with +/-(TBS) accuracy.

ID: 1165

ABI will contribute to determinations of **Sea and Lake Ice Age-CONUS** to address the following details of the threshold requirement for the Sea and Lake Ice/Age-CONUS over the CONUS: with a threshold 180 minute refresh; with a 180 minute threshold latency; at 2 km threshold resolution by using the radiance values; using 1.0 km threshold mapping uncertainty; over the range 0 - 3 years.

ID: 1166

ABI will contribute to determinations of **Sea and Lake Ice Age-Hemispheric** to address the following details of the threshold requirement for the Sea and Lake Ice/Age- Hemispheric over the full disk: with a threshold TBS minute refresh; with a TBS minute threshold latency; at TBS km threshold resolution by using the radiance values; using TBS km threshold mapping uncertainty; over the range of TBS. The goal values are to distinguish between ice free, Nilas, Grey White, First year Medium, First year thick, Second year, and multiyear smooth and deformed ice with 1 km horizontal resolution, 1 km mapping uncertainty, with a threshold 3-hour refresh; a 15 minute latency.

ID: 1168

ABI will contribute to determinations of **Sea and Lake Ice Concentration-Hemispheric** to address the following details of the threshold requirement for the Sea and Lake Ice Concentration- over the sea ice covered waters in the full disk: with a threshold TBS minute refresh; with a TBS minute threshold latency; at TBS km threshold resolution by using the radiance values; using TBS km threshold mapping uncertainty; over the range of TBS. The goal values are values of 3 hour refresh; with a 15 minute latency; at 1 km spatial resolution by using the radiance values; using 1 km threshold mapping uncertainty; over the range of ice concentration of 0/10 to 10/10 for a measurement accuracy of 5% of ice concentration.

ID: 1170

ABI will contribute to determinations of **Sea and Lake Ice Displacement and Direction -Hemispheric** to address the following details of the threshold requirement for the Sea and Lake Ice Displacement and Direction – Hemispheric over the full disk: with a threshold 180 minute refresh; with a 180 minute threshold latency; at 2 km threshold resolution by using the radiance values; using 1 km threshold mapping uncertainty; over the range of TBS and for a measurement accuracy of +/- 22.5 degrees.

ID: 1172

ABI will contribute to determinations of **Sea and Lake Ice Extent and Characterization-Hemispheric** to address the following details of the threshold requirement for the Sea and Lake Ice Extent and Characterization -Hemispheric: in the full disk: with a threshold TBS minute refresh; with a TBS minute threshold latency; at TBS km threshold resolution by using the radiance values; using TBS km threshold mapping uncertainty; over the range of TBS. The goal values are with a 60 minute refresh; with a 15 minute latency; at TBS km threshold resolution by using the radiance values; using TBS km threshold mapping uncertainty; for a measurement accuracy of TBS.

ID: 6553

ABI will measure **Sea and Lake Ice Motion: CONUS** to attempt to address the following details of the threshold requirement for the **Sea and Lake Ice Motion: CONUS** over Great Lakes and Chesapeake Bay and Delaware Bay with a threshold 180 minute refresh; with a 60 minute threshold latency; at 5 km threshold resolution by using the radiance values; using < / = 2.5 km threshold mapping uncertainty; for a measurement range on Direction of 0 - 360 degrees and on displacement of 0 - 0.6 m/s, and a measurement accuracy on direction of + / - 15 degrees.

ID: 6355

ABI will measure **Sea and Lake Ice Motion: Hemispheric** to attempt to address the following details of the threshold requirement for the **Sea and Lake Ice Motion: Hemispheric** over the sea ice covered waters in the Northern and Southern Hemispheres with a threshold 6 hour refresh; with a 60 minute threshold latency; at 15 km threshold resolution by using the radiance values; using < / = 7.5 km threshold mapping uncertainty; for a measurement range on Direction of 0 - 360 degrees and on displacement of 0 - 0.6 m/s, and a measurement accuracy on direction of + / - 15 degrees.

ID: 1175

ABI will measure **Sea Surface Temperature-Coastal** to attempt to address the following details of the threshold requirement for the Sea Surface Temperature-Coastal: with a threshold 180 minute refresh; with a 1-3 hours threshold latency; at 0.3 km threshold resolution by using the radiance values; using 0.3 km threshold mapping uncertainty; for a measurement range of 271-313 K and a measurement accuracy of 0.1 K.

ID: 1176

ABI will measure **Sea Surface Temperature- CONUS/Offshore** to attempt to address the following details of the threshold requirement for the Sea Surface Temperature- CONUS/Offshore: with a threshold 180 minute refresh; with a 60 minute threshold latency; at 2 km threshold resolution by using the radiance values; using 1 km threshold mapping uncertainty; for a measurement range of 270-313 K and a measurement accuracy of 1.0 K.

ID: 1177

ABI will measure **Sea Surface Temperature-Hemispheric** to address the following details of the threshold requirement for the Sea Surface Temperature-Hemisphere: with a threshold 60 minute refresh; with a 15 min threshold latency; at 2 km threshold resolution by using the radiance values; using 1 km threshold mapping uncertainty; for a measurement range of 270-313 K and a measurement accuracy of 1 K.

ID: 1178

ABI will measure **Sea Surface Temperature-Mesoscale** to address the following details of the threshold requirement for the Sea Surface Temperature- Mesoscale: with a threshold 60 minute refresh; with a 15 min threshold latency; at 2 km threshold resolution by using the radiance values; using 1 km threshold mapping uncertainty; for a measurement range of 270-313 K and a measurement accuracy of 1 K.

ID: 1179

(2.10.1) 3A. Top Priority Requirements

ID: 1180

The following four requirements are considered to be the highest priority by NOAA's National Weather Service for the imager:

ID: 1181

(2.10.1) 3.A.1. Operation during eclipse and keep out zone periods

ID: 1182

The imager shall be capable of continuous operation during eclipse periods in geostationary orbit.

ID: 1183

Such imaging shall include acquisition of data from all bands with wavelengths greater than 3 um, and if necessary, support of navigation through the ability to observe stars in the visible range. Bands with wavelengths greater than 3 um shall meet all requirements, although there is a relaxed navigation specification described in section (2.10.1) 3.B.3.

ID: 1184

During the daily period of time prior to and following spacecraft eclipse, and during the seasonal periods just prior to and after eclipse when sunlight impinges on the imager optical path (defined by NOAA as the keep-out-zone period), the ABI shall not acquire data within 3 degrees of the sun (5 degrees for the 3.9 um band).

Discussion: Formulation studies have determined that this is the region which provides acceptable performance as defined by NOAA.

For all pixels in the annulus between 3 degrees (5 degrees for the 3.9 um band) and 7.5 degrees of the center of the sun for all spectral bands except the low light band (which is excepted out to 10 degrees), the ABI shall perform as follows:

ID: 1185

.

ID: 1186

Emitted bands shall have NEdTs no more than two times values shown in Table 3a and radiometric accuracy better than 2 degrees K.

ID: 1187

No bands shall saturate on the supplied signal level.

ID: 1188

Signal to noise, Modulation Transfer Function, Image Navigation and Registration, and Calibration Accuracy requirements for the Visible, and Reflected Solar < 3 um bands shall not apply whenever any point on the earth falls within the annulus specified above.

ID: 5871

Thus, the ABI shall meet all operational requirements (except for low light channel requirements) for all pixels outside of the 7.5-degree radius and all operation requirements for all pixels outside of the 10-degree radius from the center of the sun.

ID: 1189

Discussion: See paragraph 2.B.11 “Avoidance of Imager Damage Due to Sunlight”, a relating requirement and discussion.

ID: 1190

Discussion: Geostationary viewing geometry results in sunlight impingement on the optical path of the GOES imaging telescope during the periods of the year several weeks around each equinox. When this happens, stray sunlight may cause a degradation of the radiometric response accuracy of the imager's Earth-viewing detectors, as well as heating of the optical and structural elements of the instrument (e.g. the secondary mirror mounts). How much degradation and how long this effect lasts will depend on many design features of the imager. The imager should be designed in such a way that intrusion of sunlight from outside the field of view is minimized, reducing as much as is practical the need for "keep-out-zones” near local midnight during the equinoxes, and in addition minimize heating of secondary mirror and mount Focused sunlight on the optics is a cause of potential damage. The energy is sufficient to damage optical materials and coatings, and to irreparably damage detectors. Within 3 degrees it would not be useful to take data. The relaxation of requirements between 3 (5 degrees for 3.9 um) and 7.5 degrees (10 degrees for the low light channel) of the sun is done in recognition that stray light will contribute noise in the local midnight condition. These numbers are the result of formulation studies.

ID: 1191

Benefits: Providing near-continuous coverage through the spring and fall eclipse and keep-out-zone periods will give needed IR data of both spring severe weather and hurricanes.

ID: 1192

(2.10.1) 3.A. 2. Meet “simultaneous” global/synoptic/mesoscale imaging needs.

ID: 1193

The imager shall be capable of acquiring images over the contiguous United States (CONUS) in a duty cycle that does not prohibit acquiring images of the full Earth disk as seen from geostationary orbit “simultaneously”, in accordance with temporal resolution requirements given in Top Priority Requirement #3 (2.10.2) 3.A.3, below.

ID: 1194

Discussion: Previous GOES imaging systems were incapable of acquiring images below the equator when rapid-interval scanning of the CONUS for severe weather surveillance was invoked; nor capable of performing the required number of full disk and CONUS updates.

ID: 1195

Benefits: Retaining the regular southern hemispheric observations are advantageous to cloud motion analyses for numerical weather prediction, and for monitoring of volcanoes and synoptic-scale weather systems affecting US aviation and marine operations.

ID: 1196

(2.10.1) 3.A.3. Improve the temporal resolution of the imager.

ID: 1197

The imager shall be capable of acquiring data of a given area in both of the following time scales, although scan mode 4 is anticipated to be the normal operation mode:

ID: 1198

a) Scan mode 3: Full Earth disk (stepped-edge acceptable) every 15-minutes; plus CONUS, or the equivalent of a nadir-viewed rectangle 5000 kilometers by 3000 kilometers in dimension, every 5 minutes and at least one 1000 by 1000 kilometer area (nadir) every 30 seconds.

ID: 1199

ID: 1200

b) Scan mode 4: Full Earth disk (stepped-edge acceptable) every 5-minutes.

ID: 1201

c) The CONUS and full disk imaging shall be done concurrently with all other image activities, such as space looks, blackbody calibrations and any necessary star observations.

ID: 1202

d) The ABI image acquisition control system shall be flexible such that different observational regions and timing can be easily commanded from the NOAA-NESDIS SOCC within the general limitations of the scan rate, buffers and data rate limits of the system.

ID: 1203

ID: 1204

Discussion: NOAA will use routine five-minute image refresh for US forecast and warning missions. However, the imager shall have the capability to cover an area of at least 1000 by 1000 kilometers (as measured at nadir) in less than 30 seconds in order to provide non-routine, mesoscale surveillance of any atmospheric, oceanic, or terrestrial event that may benefit by more rapid updates.

ID: 1205

Benefits: An improved temporal resolution allows more frequent updates of the CONUS and full disk, as well as monitoring rapidly changing mesoscale events.

ID: 1206

(2.10.1) 3.A.4. Improve spatial resolution of the imager data.

ID: 1207

The imager shall produce data with the following resolution, as measured at SSP:

ID: 1208

The baseline visible band (0.64 µm) resolution shall be 0.5 km at the SSP but the exact value will be determined during the ABI formulation.

ID: 1209

a) The spatial resolution of the 0.47 um, 0.86 um, and 1.61 um bands shall be 1.0 km at the SSP.

ID: 1210

b) All other bands shall have a resolution of 2.0 km at the SSP.

ID: 1211

c) The emissive bands shall all be of the same resolution, as defined after the discussion below.

ID: 1212

Discussion: The intent of the NWS resolution requirement is to double the current GOES imager resolution to allow for better identification and tracking of cloud and moisture signatures that indicate the development of severe weather. To assure that the ABI resolution is twice that of the current imager, the requirement is defined using the instrument's system Modulation Transfer Function (MTF). MIT-LL analyses have demonstrated (and formulation has validated) that by extending the MTF specification used for the GOES I-M series imager to twice the spatial frequency, the requirement for higher resolution can be achieved. Specifying the system MTF also allows for flexibility in the design of subsystems.

ID: 1213

The MTF (i.e. resolution) system requirements of Table 1a and Table 1b shall be met by the level 1b product (after resampling). MTF between solar reflective bands should be similar to reduce artifacts in multi-band products. Similarly, MTF between emissive bands should be similar to reduce artifacts in multi-band products.

Discussion: Table 1a describes the MTF requirements for the 2.0 km bands emissive IR bands. Table 1b describes the MTF requirements for all of the 0.5 and 1.0 km bands and the reflective solar 2.0 km bands. The maximum visible spatial frequency to be measured is 1 km^{-1} or 1 km/cycle. The maximum emissive IR spatial frequency to be measured is 0.25 km^{-1} or 4.0 km/cycle.

The MTF requirement shall apply to both E/W and N/S directions after any ground processing..

ID: 1214

Table 1a. MTF Requirements for ABI Emissive IR, 2.0 km bands

Spatial Period (km/cyc)	Spatial Frequency (cyc/rad)	System MTF
16.0	2250	0.84
8.0	4500	0.62
5.333	6750	0.39
4.0	9000	0.22

ID: 1236

Table 1b. MTF Requirements for ABI Reflective solar bands yielding 0.5 km, 1.0 km bands, and 2 km resolution.

0.64 micron channel (0.5 km)			0.47, 0.86, 1.61 micron channels (1.0 km)			1.38 and 2.26 channels		
Spatial Period	Spatial Frequency	System MTF	Spatial Period	Spatial Frequency	System MTF	Spatial Period	Spatial Frequency	System MTF
km/cyc	cyc/rad		km/cyc	cyc/rad		km/cyc	cyc/rad	
4.0	9000	0.90	8.0	4500	0.90	16.0	2250	0.90
2.0	18000	0.73	4.0	9000	0.73	8.0	4500	0.73
1.333	27000	0.53	2.666	13500	0.53	5.333	6750	0.53
1.0	36000	0.32	2.0	18000	0.32	4.0	9000	0.32

ID: 1302

ID: 1303

Discussion: This requirement also represents the technical interpretation of the NWS ORD requirement on "image smearing," as stated in the 1999 NWS ORD, page 11, 12. The actual NWS ORD value of requiring 99.5% of true radiance for any field-of-view to be achieved within 3 pixels has been dropped.

ID: 1304

Benefits: Increasing the spatial resolution allows for identification of smaller scale phenomena, for example: outflow boundaries, cloud-top thermal gradients and fog.

ID: 1305

2.10.1) 3.B. Additional Imager Requirements

ID: 1306

This section details the remainder of the technical requirements derived from the GPRD-1fd, the NWS ORD, and from NOAA-NESDIS.

All navigation accuracies shall be **3 sigma** values.

ID: 1307

Table 2. ABI Requirement Summary (Partial List) *(Provided for reference only)*

Requirement Name and Source		Requirement Values
Spatial resolution and uniformity	Visible (0.64 μm band)	0.5 km (14 μrad)
	0.47 um, 0.86 um, and 1.61 um bands	1.0 km (28 urad)
	1.38 um and all bands > 2 um	2 km (56 μrad) (Table 1)
Spatial coverage	Full disk	Scan mode 4: 12 per hour Scan mode 3: 4 per hour
	CONUS (3000 x 5000 km)	Scan mode 4: no additional CONUSs Scan mode 3: 12 per hour
	Mesoscale (1000 x 1000 km) when required	Scan Mode 4: no additional mesoscales Scan mode 3: Every 30 sec
Operation during eclipse		Yes
Simultaneity		Within 5 sec. for all bands at any FOV Within 30 sec. for any adjacent (N/S) pixels Within 15 sec. for any adjacent (E/W) pixels
Number of bands		16
Spectral bands, Radiometric Sensitivity, Dynamic Range		(Table 3)
Navigation (pre-margining)		</ = 1.0 km (</ = 28 μrad) (see sec 2.10.1) 3.B.3
Registration within frame (pre-margining)		</ = 1.0 km (</ = 28 μrad) (see sec 2.10.1) 3.B.6
Line-to-line registration (pre-margining)		</= 0.25 km (at SSP) or </= 7 urad (see sec 2.10.1) 3.B.6
Registration image to image (pre-margining)		</= 0.75 km (at SSP) or </= 21 urad for 0.5 km bands and 1.0 km bands (see sec 2.10.1) 3.B.8 </= 1.0 km (at SSP) or 28 urad for 2.0 km bands (see sec 2.10.1) 3.B.8
Band to band co-registration (pre-margining)	0.5 km bands to 2.0 km bands	</= 0.3 km (at SSP) or </= 8.4 urad
	2.0 km bands to 2.0 km bands	</= 0.3 km (at SSP) or </= 8.4 urad
	0.5 km bands to 1.0 km bands	</= 0.3 km (at SSP) or </= 7 urad
	1.0 km bands to 1.0 km	</= 0.25 km (at SSP) or </= 7 urad

	bands	
	1.0 km bands to 2.0 km bands	</= 0.3 km (at SSP) or </= 8.4 urad
On-orbit calibration	Visible and reflected solar < 3 um	Pre-launch to ± 5% On-board to ± 3% 0.2% short-term repeatability
	Emissive IR	0.2 K repeatability 1.0 K abs. Accuracy
IR band linearity		± 1%
Lifetime***	Ground storage	5 years (TBR)
	On-orbit storage	5 years (TBR) is max possible
	Mean Mission Duration (MMD)	8.4 years (see section (2.10.1) 3.B.1 (TBR) years
	Instrument On life	10 years with R=0.6 (see section (2.10.1) 3.B.1)

ID: 1422

(2.10.1) 3.B.1 Lifetime:

ID: 1423

The instrument shall be designed for an 8.4 year Mean Mission Duration (MMD) at the end of 10 years. The MMD is the integrated area under the instrument reliability versus time curve.

Discussion: This mean that a 10-year instrument-on life shall be supported with Reliability (R) of 0.6.

ID: 1424

Discussion: NOAA-NESDIS studied the benefits of extending the present lifetime of the current GOES series, as well as issues associated with extending the lifetime as a way to contain and reduce program costs. Given that new instruments are required to meet NOAA requirements as well as provide replacements and new designs, it was timely to look at the longer life. However, long life may be traded against the insertion of new capabilities and/or technologies. Major long lifetime issues would be: Avoiding single point failure designs, long life evaluation through accelerated lifetime testing of selected components such as mechanisms, thermal control of optics and electronics, analyses such as FMECA (Failure Mode, Effects and Criticality Analysis).

ID: 1425

Benefits: Extending the lifetime will save money by reducing program costs.

ID: 1426

(2.10.1) 3.B.2. Types of observations and accuracies:

ID: 1427

To enable the generation of meteorological and environmental products needed for operational NWS uses, ABI shall yield observations according to the following table of bands, defined by center wavelength and bandwidth, measurement ranges, maximum radiances, and noise. In addition, ABI shall support navigation.

ID: 1428

Discussion: If star sensing in the visible down the optical path of the instrument is employed to support navigation, star sensitivity may permit four (4) stars to be observed at least 95% of the time and 1 star at all times.

ID: 1429

Table 3: ABI Band Descriptions

ID: 1430

Table 3a. Radiometric Sensitivity and Dynamic Range

Wavelength (µm)	NEdT @300K (K)	NEdT @240K (K)	NEdN, or SNR at 100% albedo ($mW/m^2/sr/cm^{-1}$)	Tmin (K)	Tmax (K)	Rmax ($mW/m^2/sr/cm^{-1}$)	Rmax/ NEdN
0.47 +/- 0.02	-	-	300:1	N/A	-	14.4	-
0.64 +/- 0.05	-	-	300:1	N/A	-	21.1 (day) 1.05 (night)	-
0.86 +/- 0.02	-	-	300:1	N/A	-	22.8	-
1.38 +/- 0.015	-	-	Now 300:1	N/A	-	21.7	-
1.61 +/- 0.03	-	-	300:1	N/A	-	20.0	-
2.26 +/- 0.025	-	-	300:1	N/A	-	12.1	-
3.9 +/- 0.1	0.10	1.4	0.004	4	400	19.7	4925
6.185 +/- 0.415	0.10	0.4	0.05	4	300	21	420
6.95 +/- 0.2	0.10	0.37	0.09	4	300	37	411
7.34 +/- 0.1	0.10	0.32		4	320 K	67.3	
8.5 +/- 0.2	0.10	0.27	0.13	4	330	116	892
9.61 +/- 0.19	0.10	0.22		4	300	93.2	
10.35 +/- 0.25	0.10	0.21	0.17	4	330	161	947
11.2 +/- 0.4	0.10	0.19	0.17	4	330	176	1035
12.3 +/- 0.5	0.10	0.18	0.18	4	330	190	1118
13.3 +/- 0.3	0.30	0.48	0.53	4	305	150	283

ID: 1585

Discussion: For the ABI, both visible and "visible" refer to the band with a center wavelength near 0.64 um. The reflected solar bands with wavelengths < 3 um refers to all bands with center wavelength's between 0.47 um and 3.0 um, except for the “visible” band just defined.

ID: 1586

The maximum temperature for each band shall be at least what is specified in the above table through out the lifetime of the instrument. Also, for calibration purposes, all IR bands shall not saturate below the maximum expected blackbody temperature. The NEdT requirements must be met even at end of life.

ID: 1587

Due to the increased spatial resolution of the ABI, the temperature maximum for the 3.9 µm band shall be at least 375 K to maintain the current (GOES-8 and GOES-M and beyond) fire detection capability.

Discussion: The NEdT requirement is relaxed (although less than 0.5 K) for scene temperatures greater than 330 K. GOES is the only platform that can adequately sample the important temporal aspect of the majority of fires. The identification of fires is a NWS requirement. The 375 K temperature value must allow for adequate signal quantization. As a result of studies, the chosen temperature value is 400 K.

ID: 1588

Benefits: The selection of bands has been optimized to meet all cloud, moisture, and surface observations requirements to support the NWS mission of weather and other forecasting.

The phenomena observed and the critical applications are described by band:

ID: 1589

a) 0.47 um band: Daytime aerosol-on-land/coastal water mapping

ID: 1590

b) Visible (0.64 µm band): Daytime cloud imaging; snow and ice cover; severe weather onset detection; low-level cloud drift winds; fog; smoke; volcanic ash; flash flood analyses, hurricane analysis; winter storm analysis

ID: 1591

c) .86 µm: Provides synergy with the AVHRR/3, as the band is similar to band 2 on AVHRR/3. This band is used for determining vegetation amount, aerosols and ocean/land studies. Characterizing aerosols and their optical properties is essential for improving a number of satellite products, for example SST, ocean color and surface temperatures. This band also enables very localized vegetation stress monitoring, fire danger monitoring, and albedo retrieval.

ID: 1592

d) 1.38 µm: Similar to a band on MODIS that sees into the lower troposphere due to water vapor sensitivity and thus it provides excellent daytime sensitivity to very thin cirrus. This will aid several products relying on clear skies in the infrared windows, for example SST. CIMSS work with MODIS data in this band has indicated that out of band signal contamination of 0.5% compared to the signal in this band threatens the quality of this product and thus 0.25% out of band signal contamination shall not be exceeded. Out of band contamination for all other bands shall not exceed the 1.0% level.

ID: 1593

e) 1.61 µm: Daytime cloud/snow/ice discrimination; total cloud cover; aviation weather analyses for icing; smoke from low-burn-rate fires

ID: 1594

f) 2.26 um: Daytime land/cloud properties, particle size, and vegetation

ID: 1595

g) 3.9 µm: Fog and low-cloud discrimination at night; fire identification; volcanic eruption and ash; daytime reflectivity for snow/ice

ID: 1596

h) 6.185 µm: Upper-tropospheric water vapor tracking; jet stream identification; hurricane track forecasting; mid-latitude storm forecasting; severe weather analysis

ID: 1597

i) 6.95 µm: Middle-tropospheric water vapor tracking; mid-tropospheric flow tropical storm track prediction weather; winter storm analyses

ID: 1598

j) 7.34 um: Lower tropospheric water vapor tracking and SO_2 detection

ID: 1599

k) 8.5 µm: Allows for detection of volcanic cloud with sulfuric acid aerosols, thin cirrus in conjunction with the 11 um band and determination of cloud micro-physical properties with the 11.2 and 12.3 um bands. This includes a more accurate delineation of ice from water clouds during the day or night.

ID: 1600

l) 9.61 um: Total Ozone

ID: 1601

m) 10.35 µm: Allows for determination of micro-physical properties of clouds with the 11.2 and 12.3 um bands. This includes a more accurate determination of cloud particle size during the day or night.

ID: 1602

n) 11.2 µm: Continuous day/night cloud analyses for many general forecasting applications; precipitation estimates; severe weather analyses and prediction; cloud drift winds; hurricane strength and track analyses; cloud top heights; volcanic ash; fog (in multi-band products); winter storms; cloud phase/particle size (in multi-band products)

ID: 1603

o) 12.3 µm: Continuous cloud monitoring for numerous applications; low-level moisture; volcanic ash trajectories; cloud particle size (in multi-band products)

ID: 1604

p) 13.3 µm: Cloud top height assignments for cloud-drift winds; cloud products for ASOS supplement; tropopause delineation; cloud opacity

ID: 1605

Table 3.b. 16 CHANNEL IMAGER BAND DESCRIPTION

Wave-length Microns	Prior -ity	Upper and lower 50% response points (in microns)	Noise @ Ref.	Max. Level	Purpose
0.47	Core	0.45±0.01 - 0.49±0.01	300/1	100 %	Daytime aerosol-on-land/coastal water mapping
0.64	Core	0.59±0.01 - 0.69±0.01	300/1	100 %	Daytime clouds
0.86	Core	0.84±0.01 - 0.88±0.01	300/1	100 %	Daytime vegetation & aerosol-on-water
1.38	Core	1.365±0.005 - 1.395±0.005	300/1	100 %	Daytime cirrus cloud
1.61	Core	1.58±0.01 - 1.64±0.01	300/1	100 %	Daytime cloud water, snow
2.26	Core	2.235±0.01 - 2.285±0.01	300/1	100 %	Daytime land/cloud properties, particle size, vegetation
3.90	Core	3.80±0.05 - 4.00±0.05	0.1 K	400 K	sfc. & cloud/fog at night, fire
6.185	Core	5.77±0.03 - 6.6±0.03	0.1 K	300 K	high. water
6.95	Core	6.75±0.03 - 7.15±0.03	0.1 K	300 K	mid water
7.34	Core	7.24±0.02 - 7.44±0.02	0.1 K	320 K	low water & SO_2
8.5	Core	8.3±0.03 - 8.7±0.03	0.1 K	330 K	total water for stability, cloud phase, dust, SO_2
9.61	Core	9.42±0.02 - 9.8±0.03	0.1 K	300 K	total ozone
10.35	Core	10.1±0.1 - 10.6±0.1	0.1 K	330 K	sfc. & cloud
11.2	Core	10.8±0.1 - 11.6±0.1	0.1 K	330 K	total water for SST, clouds
12.3	Core	11.8±0.1 - 12.8±0.1	0.1 K	330 K	total water & ash, SST
13.3	Core	13.0±0.06 - 13.6±0.06	0.3 K	305 K	air temp & cloud heights and amounts

ID: 1726

Benefits: The improved spectral coverage enhances current products and affords new products.

ID: 1727

Discussion: It is NOAA’s understanding that the signal quantization may be about 12 bit for the IR bands and about 14 bits for the 3.9 µm band.

ID: 1728

The dominant direction of instrument "scan" shall be in the East-West (or West-East) directions. To accommodate a possible Yaw flip, stepping shall be possible in both North to South and South to North directions.

ID: 1729

If the NEdT specifications for the IR window bands (8.5, 10.35, 11.2 and 12.3 µm) at 300 K are exceeded to the 0.05 K, then the quantization shall be of ½ of the NEdT to recover margin in the bands.

ID: 5885

The relative accuracy of each band shall be within the NEdN (1-sigma) for the following categories of relative error: a) swath to swath (where a swath is one traversal of the scan mirror in the east-west directions over the entire scene of interest), b) detector to detector, c) channel to channel, d) calibration to calibration.

Discussion: If the vendor exceeds this requirement, quntization of 1/3 of the NED N is considered sufficient.

ID: 5886

It is understood that the engineering solution will involve focal plane arrays and thus crosstalk effects and blooming effects may contribute to signal uncertainties in non-uniform scenes, such as broken bright clouds over a darker scene. Other sources of crosstalk in the ABI would yield unwanted signal increases. At a minimum, the crosstalk contribution from a full-scale signal from a neighboring pixel shall be less than or equal to the derived NEdN in the relevant band.

ID: 1730

(2.10.1) 3.B.3. Imager System navigation

ID: 1731

Imager System navigation (Earth location) errors shall not exceed 1.0 kilometer at the SSP (3-sigma), except during eclipse. For up to a 4-hour period including the eclipse of the sun, the navigation shall be relaxed to 1.5 km at the SSP or 42 urad. The phasing of the four hours relative to midnight will be recommended by the contractor. Image navigation refers to the precision to which the longitude and latitude of each pixel within an image can be determined. The determination of location and registration will be via the centroid of the spatial response of the pixel. (See also Additional Requirement #3B 6)

ID: 1732

ID: 1733

Discussion: NOAA is aware that several requirements, notably in navigation and registration, that are difficult to achieve by traditional means. Ground processing (see 3.C.1) will be required to meet these requirements. An oversampled IR ground sample distance, in both directions, is required to ensure radiometrically accurate 2-km resolution IR products (see 3.B.4). MIT-LL has looked at spatial sample rates necessary for accurate ground processing and found several potential benefits. A 1-km sample rate in the IR bands is close to the Nyquist frequency for the system MTF of Table 1 and the corresponding optics and detector sizes envisioned for ABI. Since the data are nearly Nyquist sampled, the imagery can be reconstructed to any sample spacing with little radiometric error.

ID: 1734

During formulation, vendor studies results were employed by the government to finalize the requirements listed above; it is important to note that these numbers have not been margined. This requirement shall be met by the entire imager system and employs sampling at finer spatial resolution than the product together with ground processing to provide the navigation performance listed above.

ID: 1735

ID: 1736

Benefits: Accurate navigation on all images is essential to accurate forecast product generation at NOAA. Accurately navigated imagery allows trouble-free merger with other data sources, improved knowledge of the location of surface-based features and provides higher forecaster confidence in image interpretation, especially in applications demanding image animation.

ID: 1737

(2.10.1) 3.B.4. Data format

ID: 1738

The data format must allow integration of imager data with other NOAA and other coincident data sources. To facilitate data use and integration, the distributed, calibrated, navigated ABI data shall be rectified to a fixed grid. The grid is defined as the 'perfect' satellite projection from a given longitude and geostationary orbit, similar to the current GOES-N fixed grid. The distributed data samples shall have an angular separation of 14 microradians (visible, 0.64 um), 28 microradians (0.47 um, 0.86 um, and 1.61 um) and 56 microradians (1.38 um, all wavelengths longer than 2 um) in both the East/West and North/South dimensions.

ID: 1739

Discussion: Integrating geostationary imager data with other meteorological data, such as doppler radar (WSR-88D), numerical model output, and in situ observations from networks like ASOS, ACARS, and lightning detection sensors, is a critical capability of NWS forecast processes. Imager data format must be documented to allow for such integration.

ID: 1740

Benefits: In addition to data fusion, this regular, orthogonal coordinate system allows for consistent estimations of feature sizes, distances and motions.

ID: 1741

(2.10.1) 3.B.5. Co-registration

ID: 1742

Co-registration errors between infrared imager bands having 2.0 km spatial resolution shall not exceed 0.3 km (at SSP) or 8.4 urad. This requirement is for the total imager system as described in Section 2.

ID: 1743

The co-registration error between each of the infrared imager bands having 2.0 km spatial resolution and the visible band (0.5 km) shall not exceed 0.3 km (at SSP) or 8.4 urad and shall be determined by centroiding a set of visible FOV's to determine a "mean" visible FOV equal in extent to the IR FOV.

ID: 1744

The co-registration error between each of the infrared imager bands having 2.0 km spatial resolution and the infrared imager bands having 1.0 km spatial resolution shall not exceed 0.3 km (at SSP) or 8.4 urad and shall be determined by centroiding a set of 2x2 visible FOV's to determine a "mean" visible FOV equal in extent to the IR FOV.

ID: 1745

The co-registration error between each of the infrared imager bands having 1.0 km spatial resolution and the infrared imager bands having 1.0 km spatial resolution shall not exceed 0.25 km (at SSP) or 7 urad.

ID: 1746

The co-registration error between each of the infrared imager bands having 1.0 km spatial resolution and the visible band (0.5 km) shall not exceed 0.3 km (at SSP) or 8.4 urad and shall be determined by centroiding a set of 4x4 visible FOV's to determine a "mean" visible FOV equal in extent to the IR FOV.

ID: 1747

Discussion: Co-registration error should be minimized the most for the important bands that can sense the rapidly changing surface (i.e. 8.5, 10.35, 11.2, 12.3, 13.3 μm). These co-registration errors reflect the results of vendor formulation studies and government review, but it is important to note that these are the pre-margining value.

ID: 1748

Benefits: The combination of two or more imager bands is often needed to generate secondary products for specific forecast applications. Nighttime fog, for instance, can be distinguished readily by differencing the short-wavelength and window IR bands in high spatial resolution images. Accurate co-registration of bands is essential to generation of radiometrically and geographically accurate high-resolution analyses.

ID: 1749

(2.10.1) 3.B.6. Pixel-to-pixel registration within frame:

ID: 1750

Within an image in the same channel, any two pixels shall be separated by the known fixed distance to within 1.0 km at SSP, or 28 urad.

ID: 1751

Line-to-line registration. Any two adjacent lines or swaths, East/West and North/South, within an image shall be separated by the nominal distance to within 0.25 km at SSP, or 7 urad.

ID: 1752

Discussion: These requirements are intended to define the limits of acceptable within-image distortions but also reflect improvements as a result of vendor formulation trade studies. These numbers are pre-margining.

ID: 1753

Benefits: Measurement of feature size and distance, in addition to image quality, require accurate within frame and line-to-line registrations.

ID: 1754

(2.10.1) 3.B.7. Removed

ID: 1755

(2.10.1) 3.B.8. Frame-to-Frame Registration

ID: 1756

Frame to frame (or image to image) registration error is the difference in navigation error for any given pixel in two consecutive images within the same channel. The frame-to-frame registration shall be 21 urad for the channels with 0.5 km and 1.0 km spatial resolution. The frame-to-frame registration shall be 28 urad for the channels with 2.0 km spatial resolution.

ID: 1757

(2.10.1) 3.B.9. Data simultaneity:

ID: 1758

a) Data from all imager bands obtained for any specific point on Earth shall be coincident within 5 seconds.

ID: 1759

b) All adjacent detector samples in the N/S direction from any one band for any given image shall be observed within 30 seconds of each other.

ID: 1760

c) At least 99.5% of adjacent detector samples in the E/W direction from any one band for any given image shall be observed within 15 seconds of each other.

ID: 1761

Discussion: Part a) of this requirement is needed to ensure accurate interpretation of image applications that are based on comparison of images in different bands. Part b) is based on engineering assumptions that focal plane array detectors may be used in imager designs. Where line or area arrays are to be used in east-west scanning, the time gap between successive swaths must be minimized to avoid introducing artifacts across the swath boundaries in reconstructed images. The intent of Part c) is that once a set of lines has begun to be scanned, the scanning of those lines should be completed. (Formulation studies have shown that certain types of scan methods will produce a small number of E/W neighbors originating from different scan lines. This same effect also requires resampled pixels be generated from detector samples taken from the same swath.) To address this, NOAA has defined a requirement for the maximum allowable time of adjacent pixel simultaneity. If this time is too short, imager design ramifications may be serious. If this time is too long, (i.e., too lenient), then deformations may be observed in swath boundaries of images.

ID: 1762

Discussion: As stated in part b), above, NOAA's requirement for adjacent pixel simultaneity is now defined as at least 30 seconds for all scanning scenarios. In a worst case, where a motion of cloud features is along the scan axis, artifacts resulting from the delay between scanning sequential swaths will be greatest. The table below summarizes the apparent north-south shift of cloud fields, in pixels, that would result from northerly winds, using a 30-second pixel simultaneity specification:

ID: 1763

Apparent Shift Ratio (In 2-km infrared pixels)

ID: 1764

Resulting from 30-second scan-swath offset on notional ABI with east-west scanning

ID: 1765

Wind Speed (N)		Pixels offset, nadir	Pixels offset, 35N (at subpoint longitude)
0 km/hr	0 m/s	0.00	0.00
10	2.8	0.04	0.03
25	6.9	0.10	0.07
50	13.8	0.21	0.14
100	27.8	0.42	0.28
200	55.6	0.83	0.56

ID: 1766

ID: 1767

ID: 1768

ID: 1769

ID: 1770

ID: 1771

ID: 1772

These numbers demonstrate the rationality of NOAA's 30-second simultaneity requirement: For fast wind fields (around 200 km/hr or ~120mph) typically associated with jet-stream cirrus clouds, the maximum cross-swath deformation artifact will be less than one 2-kilometer pixel at nadir. Higher wind speeds do occur in jet cirrus, but rarely at lowest latitudes, and rarely blowing due north (or south), and rarely in excess of 260 km/hr

ID: 1773

Benefits: Improved wind and image quality.

ID: 1774

(2.10.1) 3.B.10. Full Operations:

ID: 1775

The ABI shall achieve full operations within 1 hour following spacecraft maneuvers.

ID: 1776

Discussion: Routine operations should not be re-established too quickly to endanger the health or safety of the instrument. The design should minimize degradation to navigation ability from sun exposure on the scan mirror and the rest of the imager.

ID: 1777

Benefits: Excessive delays in resuming routine imaging operations following mandatory outages associated with maneuvers can threaten continuity of weather surveillance and result in degradation of forecasts of severe weather.

ID: 1778

(2.10.1) 3.B. 11. Avoidance of ABI Damage Due to Sunlight

ID: 1779

ABI shall be designed to prevent sunlight from damaging any part of the imager. ABI shall go into a safe mode when the instrument determines an at-risk situation or when the spacecraft instructs the instrument to self-protect.

ID: 1780

Discussion: Focused sunlight on the optics is a cause of potential damage. The energy is sufficient to damage optical materials and coatings, and to irreparably damage detectors, especially the IR detectors. Two sources of damage have been identified. The first is operational imaging when the sun is in the field of regard. The keep out zone addresses this. The second is when the spacecraft goes off of sun and earth lock either for routine or unplanned maneuver.

ID: 1781

(2.10.1) 3.B.12. Reflected Solar calibration:

ID: 1782

a) The “Visible” band and the other reflected solar bands with wavelengths less than 3 um shall be calibrated prior to launch to provide albedo to an accuracy of ± 5% at maximum scene radiance. The bands shall be quantized in such a way that the signal will not saturate (high counts or low counts) over the life of the instrument and under worst-case conditions.

ID: 1783

b) The ABI shall have an on-board "visible" and reflected solar < 3 um calibration capability for the imager. Onboard calibration shall provide:

ID: 1784

1. Absolute radiometric calibration accuracy of 3.0%

ID: 1785

2. Relative calibration deviations (short-term repeatability) of 0.2%

ID: 1786

3. Drift in measured radiances, over the lifetime of the ABI, of 0.5%.

ID: 1787

4. Radiance measurements in the reflected solar wavelength range shall be traceable to NIST standards. Assurance of radiance traceability to NIST shall include both 1) a measurement assurance program (an example of which would be to employ NIST transfer radiometers to the vendor's calibration sources pre-launch and another example of which is the purchasing of NIST sources (e.g., lamps, blackbodies) with adherence to specified recalibration schedules pre-launch), and 2) use of NIST best practices in radiance determinations, including quality programs detailing measurement procedures and reproducibility and using trained personnel.

ID: 5873

5. The solar reflectance bands < 3 um shall be adequately calibrated to ensure that the calibration requirements are met.

Discussion: NOAA anticipates on-board calibration be performed at least once a month under routine operations and more frequently (e.g., once a day) during post-launch phase when rapid changes are anticipated.

ID: 5874

6. The calibration shall also employ a technique involving measurements to address long-term stability for the solar reflective wavelengths.

ID: 5876

7. The instrument vendor shall perform at least a pre-launch full-system radiometric calibration in all bands, filling the aperture and the entire optics/detector train as under the operational conditions.

ID: 5879

8. The vendor shall characterize the spectral response as a function of wavelength for each optical element in the optical train.

ID: 5880

9. An independent laboratory approved by the government shall measure the spectral response of witness samples of the critical optical elements, namely the bandpass optical filters.

ID: 1788

Discussion: NOAA wants an onboard, reflected solar < 3 um calibration capability, but it must not introduce significant costs or risks through its approach or technology to the ABI's lifetime. A failure of the onboard calibration device shall not cause failure of the entire ABI mission. Complementary multiple techniques can be used to implement calibration. A NOAA workshop held on May 19, 1999 explored the availability of onboard ABI visible and near IR technologies and approaches. The results of the workshop are contained in JPL report "In Flight Visible and Near Infrared Calibration of Future GOES Imagers Workshop report," Dave Norris, October 1999, JPL report D-17846. The above onboard calibration requirements identified at the workshop were discussed as limits of what could be achieved. Ultimately, the lowest GPRD product accuracy of 5% is the driver. Thus the radiomatric calibration will be tighter, at 3%. What NOAA wants is an onboard capability and some progress towards these limits.

ID: 1789

Discussion: Alternative Imager, on-board, reflected solar < 3 um calibration designs were discussed, such as

ID: 1790

1. Stable on-board source of illumination;

ID: 1791

2. The sun as a radiometric source via, e.g., reflection from diffuser plates or transmission through perforated plates.

ID: 1792

Standard diodes could be used with the preceding approaches to monitor the output of the on-board source, the reflectivity of the diffuser plate, or the transmittance of the perforated plate.

ID: 1793

Benefits: Visible calibration, enabling accurate radiation measurements, will support such products as insolation at the surface, aerosol burden over the oceans, snow mapping, correction of sea surface temperatures from over the ocean derived aerosols, reducing the appearance of "seams" between image composites derived from different satellites.

ID: 5883

Discussion: Instrument intercomparison across platforms in all wavebands will be performed by NOAA, but nothing additional is mandated to the instrument vendor because of this plan.

ID: 1794

(2.10.1) 3.B.13. Emissive Infrared Calibration

ID: 1795

Full-system and full-aperture calibration shall be provided to achieve brightness temperature absolute accuracy of 1 degree Kelvin and relative precision of 0.2 degrees Kelvin for each band.

ID: 1796

Discussion: Quantitative products derived from imager data for weather forecasting demand stable, calibrated data. Accurate knowledge of the system spectral response function (SRF), including both in-band and out-of-band response, is required for each band and the on-board black body is required. Relative precision includes line-to-line, detector-to-detector, and frame-to-frame repeatability of the measurement of the brightness temperature of a uniform scene.

The output of the instrument in each band shall be digitized in such a way that the signal will not saturate (high counts or low counts) over the life of the instrument and under worst-case conditions.

ID: 1797

Radiometric accuracy of the ABI system should be independent of scan position (or location of the target in the field of regard).

Discussion: Mirror emissivity measurements are typically measured by looking at space, and thus the field of regard of the aperture must be sized accordingly.

ID: 5875

Radiance measurements in the thermal infrared wavelength range shall be traceable to NIST. Assurance of radiance traceability to NIST shall include both 1) a measurement assurance program, an example of which would be to employ NIST transfer radiometers to the vendor's calibration sources pre-launch or the purchasing of NIST sources (e.g., lamps, blackbodies) and adhering to specified recalibration schedules pre-launch, and 2) use of NIST practices in radiance determinations, including quality programs detailing measurement procedures and reproducibility and using trained personnel.

ID: 1798

Benefits: All IR images and products rely on accurate calibration.

ID: 5877

The instrument vendor shall perform a pre-launch full-system radiometric calibration in all bands, filling the aperture and the entire optics/detector train as under the operational conditions.

ID: 5881

An independent laboratory approved by the government shall measure the spectral response of witness samples of the critical optical elements, namely the bandpass optical filters.

ID: 5878

The vendor shall characterize the spectral response as a function of wavelength for each optical element in the optical train.

ID: 5882

Discussion: Instrument intercomparison across platforms will be performed by NOAA, but nothing additional is mandated to the instrument vendor because of this plan.

ID: 1799

(2.10.1) 3.B.14. Low-light Imager

ID: 1800

There is a need for low-light dawn/dusk visible band imaging capability; not only for meteorological products, but also as an aid to improve navigation via star mapping and landmarks. The ABI shall include a low light level (5% albedo) visible (0.64 microns) imaging capability at 50:1 SNR with performance equivalent to the 0.64 microns visible channel.

ID: 1801

For the low light visible, no performance level shall be required during any eclipse period when the any point on the earth is within 10 degrees of the sun.

ID: 1802

Discussion: Star mapping, if chosen for navigation, may permit four (4) stars to be observed at least 95% of the time and 1 star at all times. The feasibility of introducing low light capability to the ABI is analyzed in JPL report JPL D-18485, JPL contract Task Plan 80-4867, Task 15 "Potential Low Light Level Visible Imaging Capability for the Advanced Baseline Imager for GOES", February 2000, Hal Sobel. Further study of the low light capability has been conducted during formulation phase studies.

ID: 1803

Benefits: One-half kilometer resolution, low-light visible imagery would allow forecasters to discern fog and important thunderstorm outflow boundaries earlier in the morning, as well as later into the evening hours, during severe and tornadic storm events.

ID: 1804

(2.10.1) 3.B.15 Autonomous Override

ID: 1805

Ground commands shall inhibit any autonomous function upon command.

ID: 1806

(2.10.1) 3.C. Requirements derived from Engineering Studies

ID: 1807

In conducting concept studies and technology and risk trade analyses, NOAA has determined several preferred instrument characteristics that are described here as design or engineering requirements:

ID: 1808

(2.10.1) 3.C.1. Ground processing needs

ID: 1809

Where the imager design requires that ground processing of image data be done in order to meet certain data specifications (e.g., co-registration, MTF matching across IR bands, navigation accuracies), then such processing shall be included in the overall imager system design."

ID: 1810

Discussion: NOAA recognizes that some optical designs may be simplified or allow for delivery of better quality data meeting defined image quality specifications if certain aspects of data processing are performed with ground equipment. Any ground processing aspects of the "imager system" must still allow the stated timeliness requirements to be met.

ID: 1811

Discussion: There are several requirements that can be aided by ground processing and adequately sampled imagery. It is possible, with sufficient information, to resample the IR imagery to correct for navigation, registration and co-registration errors. Matching of system MTF across IR bands is possible with digital filters in ground processing. Instead of detector geometry dominating the spatial response to achieve band independent resolution, any detector and aperture size combination that satisfies the system MTF requirement can be normalized across bands on the ground. Nighttime IR land marking is more accurate with the current required resolution, aiding the challenging INR requirements. The enhanced land marking ability also enables better determination of non-static co-registration errors.

ID: 1812

Algorithms and hardware capable of verifying all instrument parameters at the output of any ground-processing running at rates comparable with scanning rates will be developed. This is to ensure any proposed processing is achievable within the limits described in this section.

ID: 1813

(2.10.1) 3.C 2. Removed requirement

ID: 1814

(2.10.1) 3.C.3. Limits to Downlink Data Rates

ID: 1815

NOAA assumes that the GOES spacecraft communications system will serve to relay ABI data to NOAA ground receive systems in real time and not store-and-forward it. Currently, the ABI data rate is 60 Megabits per second (Mbps).

ID: 1816

Discussion: The results of ABI formulation studies has indicated that an ABI data rate of 60 Megabits per second (Mbps) is reasonable and reflects NOAA's current plan to increase data rates through the use an of X-band for the sensor data downlink. This data rate is a combination of lossy compression of some of the reflected solar bands and lossless compression the emissive IR bands, detailed in the section below. The X-band frequency requests are detailed in an appendix to this document.

ID: 1817

ID: 1818

(2.10.1) 3.C.4. Data compression acceptability

ID: 1819

NOAA recognizes that in order to meet both timeliness requirements on the products and downlink data bandwidth limitations, some form of image data compression may need to be invoked. The following summarizes acceptability of lossless and lossy compression.

ID: 1820

Compression of the 1.38 um band and of the all the band with wavelengths > 2 um shall be carried out by any means (e.g., Huffman coding, arithmetic coding, Rice algorithm) which permit lossless reconstruction of the data.

ID: 1821

Compression of visible (0.64 um), 0.47 um, 0.86 um, and the 1.61 um bands data shall meet the requirements outlined in Table 4.

Discussion: The peak SNR requirement ensures that the signal-to-noise ratio of the original image is preserved. The correlated noise metric measures the amount of correlated noise, or "blocking artifacts", that is often present in compressed images. This type of distortion typically occurs with compression algorithms that independently code sub-images or blocks of the original image, and is known to be very apparent to the human eye. The referenced metric computes a weighted average of vertical and horizontal edges present in the image where the weights are determined by the surrounding neighborhood contrast. The requirement allows for a 10% increase in distortion. This level was found to be consistent with subjective evaluations of image quality.

ID: 1822

In addition to the requirements in Table 4, the spatial frequency content of the original image shall be maintained so that the system MTF requirement (see above) is met after compression.

Discussion: Experience with the Joint Photographic Experts Group (JPEG) compression algorithm and visible imagery has shown that the stated requirements can be met using at least a 3:1 compression ratio.

ID: 1823

Table 4. Visible (0.64 um), 0.47 um, 0.86 um and 1.61 um Data Compression Requirements

Metric	Definition	Requirement
Peak SNR	See first equation below for PSNR where MxN is the image size, Nmax is the maximum scene radiance described in Table 3 above, Xij refers to the original imager and Xij refers to the reconstructed image.	PSNR >= 50dB
Correlated noise	M=0.5*(MhGBIM +MvGBIM), where MhGBIM and MvGBIM are defined in [1]	See second equation below where M_{RC} is the metric for the reconstructed image, and M_{ORIG} is for the original image

ID: 6335

<Picture>

ID: 6336

<Picture>

ID: 1837

[1] H.R. Wu, "A New Distortion Measure for Video Coding Blocking Artifacts," in Proceedings of the 1996 International Conference on Communication Technology, vol. 2, May 5-7, 1996, Beijing, China, pp. 658-661.

ID: 1838

The ABI shall be capable of switching between lossy and lossless on orbit, upon command, although the 60 Mbps data rate will not apply if the data compression is commanded off.

ID: 1839

Commanded switching from lossy to lossless shall be on a band-by-band basis.

ID: 1840

(2.10.1) 3.C.5. Space Environment

ID: 1841

The instrument shall be designed to withstand electrostatic charging and radiation effects which may be expected in a geosynchronous orbital environment between 75 degrees West and 135 degrees West.

ID: 1842

(2.10.1) 3.C 6. Stray Magnetic Fields

ID: 1843

The change in the magnetic field of the instrument module associated with any instrument operation shall be less than 20 nT, peak to peak, in any axis when measured at a distance of 1 meter from any face of the scan mechanism. The change in the magnetic field of any other instrument module (e.g. power supply or electronics) associated with any instrument operation shall be less than 10 nT, peak to peak, in any axis when measured at a distance of 1 meter from any face of that module.

ID: 1844

(2.10.1) 3.C.7. Linearity

ID: 1845

The linearity of the IR bands, before calibration, shall be measured prior to launch, and must be within ± 1%. There is no linearity requirement above the 375 range for the 3.9 um band.

ID: 1846

(2.10.1) 3.C 8. Spacecraft Interface Design Goals:

ID: 1847

a) Cooling: The IR detectors shall be passively cooled or actively cooled.

ID: 1848

b) Operational Conditions: It is anticipated there may be a spring and fall Yaw Flip. After such a flip (considered a maneuver), the instrument shall be able to meet all of its requirements within 1 hour.

ID: 1849

(2.10.1) 3.C.9. Future Growth

ID: 1850

Design features, which support modular improvements are advantageous.

ID: 1851

(2.10.1) 3.C.10. Operability

ID: 1852

ABI shall have 100% pixel operability.

ID: 1853

(2.10.1) 3.C.11. Polarization Control Requirement

ID: 1854

ABI channels with wavelengths <2 microns shall have less than 4% sensitivity to the polarization of incoming light. The difference in sensitivity to polarization between channels shall be less than 2%. The uncertainty in the sensitivity to polarization within a channel shall be less than 1% (TBR). The polarization insensitivity requirements shall be met at all Earth-viewing angles throughout the life of the mission, and, as a goal, the insensitivity requirements should be met over the entire field-of-regard.

Discussion: Halving the sensitivity to the polarization of incoming light and the uncertainty in the sensitivity to polarization would provide a benefit to NOAA.

ID: 1855

Polarization sensitivity is defined as the ratio of the difference between maximum and minimum output to the sum of the maximum and minimum output obtained when the plane of incoming 100% linearly polarized radiation is rotated through 180 degrees.

ID: 1856

(2.10.1) 3.C.12. Removed

ID: 1857

2.10.2 HES

1.

ID: 1937

(2.10.2) 1. HES Requirements Description and Overview

ID: 1938

The Hyperspectral Environmental Suite (HES) is located on a geostationary platform, specifically either the B satellites of the distributed architecture or both of the consolidated satellites described in section 2.3 of the MRD, and comprises one or multiple instruments procured under one contract. HES contains threshold and goal tasks. The threshold jobs that are assigned to the HES are Disk Sounding (DS) for temperature and moisture, severe weather/mesoscale (SW/M) sounding for temperature and moisture at improved spatial resolution, and coastal waters (CW) observations at improved spatial resolution. The goal job is the parallel task of open ocean (OO) observations, at coarser spatial resolution compared to the CW task observations Each of these tasks is described in more detail below. These threshold and goal tasks may be met with one instrument, several instruments, or multiple instruments. If all tasks are met, the HES may also provide a degraded ABI backup capability.

ID: 1939

When all tasks are met, HES will provide measurements of the traditional temperature and water vapor vertical profiles as well as measurements of the properties of the earth's surface, in particular oceans. These additional capabilities will meet the needs of NOAA in ocean areas that have not been well covered by the current imager or sounder due to lack of spectral coverage in the reflected solar spectrum, as well as high resolution spatial coverage in the coastal water. In particular, the region where most of the anomalous ocean conditions occur is the category of the estuaries, lakes, coastal waters, with water depths of less than 500 meters within about 20 km from the shore, and shelf waters, with water depths of less than about 2 km within 400 km from the shore. The open ocean, by contrast, has depths of greater than about 2 km. The ~400 km range from the shore is comprise of the ~12 nautical miles (22.22 km) of the territorial sea originating at the low tide water line and the additional 200 nautical mile width (370.4 km) from the outer edge of the territorial sea to the Exclusive Economic Zone (EEZ).

ID: 1940

(2.10.2) 2. Background Information and Design Goals for the HES

ID: 1941

The first HES will be available for flight nominally in 2012. NOAA expects that available technology should be used to design a Hyperspectral Environmental Suite that at a minimum meets this document's threshold requirements. Modularity in design should be considered where it permits introduction of improvements in successive units (i.e. GOES T or U) that may not be sufficiently mature to be included in beginning of the GOES-R series. Similarly, goal requirements that are not met initially by GOES-R may be implementable over a period either through pre-planned product improvement (P^3I) or though modularity. Critical performance parameters for the DS task of the HES are the scanning rates (i.e. spatial coverage), NEdN, and detector-optics ensquared energy. Critical performance parameters for the SW/M task of the HES are the spatial resolution and the coverage rate. Critical performance parameters for the CW task of the HES are the spatial resolution and the spectral coverage. Critical performance parameters for the OO task of the HES are the spectral coverage.

ID: 1942

In conducting concept studies and technology and risk trade analyses, NOAA has determined several preferred instrument characteristics that are described here as design or engineering requirements:

ID: 1943

(2.10.2) 2.A. Instrument Description Assumptions

ID: 1944

ID: 1945

NOAA's NWS has a need for improved vertical resolution, compared to the GOES I-M series or GOES-N-Q series sounders, for improved weather forecasting. Employing the improved spectral resolution along the CO_2, H_2O, and O_3 absorption features can deliver that improved vertical resolution. The sounding instrument or instruments will measure scene radiances that can be converted into vertical soundings of temperature and humidity through a numerical procedure (known as retrieval analysis) that is implemented (through ground processing) as part of the HES system.

ID: 1946

In order to produce the desired improved spectral resolution for the DS and SW/M tasks, energy from the earth's atmosphere will either be interfered or dispersed. An instrument employing interference for that desired spectral resolution is called an interferometric spectrometer here. An instrument employing dispersion for that desired spectral resolution is called a dispersive spectrometer. An instrument utilizing a combination of these two methods is not excluded; as more tasks are included, the method by which the desired resolution is achieved may vary with wavelength. *Any types of instruments will include resolutions and coverage of spectral regions that are either generally consistent with those described in this document or are shown to provide the same performance by either satellite or aircraft flight-testing data. See section 3.B.2.g. for further comments on wavebands.*

ID: 1947

It is anticipated that the OO task and the CW task will be met by one of three general classes of instruments: a multiple band radiometer where the number of bands is nominally less than 10, multiple band radiometer where the number of bands is nominally greater than 10, or a dispersive spectrometer yielding higher resolution at all wavelengths in the range producing more than 100 channels. Again, combination of these types is not excluded.

ID: 1948

(2.10.2) 2.B. Spacecraft Interface Design Considerations

ID: 1949

During the initial concept studies, two point designs were generated for NOAA/NESDIS by MIT Lincoln Laboratory in order to address the feasibility of requirements to perform only the DS task of the HES system. These instrument designs have volumes of approximately 1 cubic meter, apertures of no less than 30 cm, data rate of about 12 Mbps, and power consumption of ~200 W. For those studies, the mass, volume, and power consumption were assumed to be the same as on the GOES N-Q bus. However, it is anticipated that the HES may be larger with higher power consumption and larger data rates in order to perform more tasks of the HES by adding any multichannel or hyperspectral capability in the reflected solar region. HES instruments need to be compatible with either the GOES-R B satellite or a satellite in the consolidated architecture discussed in section "Constellation Description", which is currently unspecified. NOAA encourages innovative design and recognizes certain proposed instruments may offer tradeoffs between performance, cost-effectiveness, and these physical interface parameters. Such trades may result in different bus parameters.

ID: 1950

(2.10.2) 3. Performance Characteristics

ID: 1951

Requirements listed in this section for the atmosphere derive from the GOES Program Requirements Document-1 final draft (GPRD-1fd, July 2003, January 2004), which updates both the NOAA's Geosynchronous Operations Requirements Document-I (GORD-I) and the NOAA's NWS Operation Requirements Document (ORD) and frames the rationale primarily for the HES DS task performance characteristics and less formally the SW/M task performance characteristics. The requirements for the CW task as well as the OO task are derived from the GPRD-1fd. The bands in these tasks come from typical algorithms used for either geosynchronous and/or polar satellites. Additional requirements that are derived from technical concept studies and trade analyses are subsequently listed in other portions of this document.

ID: 1952

This document employs a two-level definition for most of the requirements:

ID: 1953

<u>THRESHOLD</u>: The minimum acceptable capability at end-of-life required at the beginning of the proposed series of satellites. All requirements are threshold unless noted as goals.

ID: 1954

GOAL: This is an enhanced capability level beyond the THRESHOLD level of performance needed to support future NOAA and other user operations and environmental needs. This level of performance should be achieved when technically and financially feasible, as determined by NOAA, during the series of satellites by continually infusing advances in technology that improve services with minimal effect on total project costs.

ID: 1955

Future Enhancements: Design features that would support modular improvement in moving from any of the THRESHOLDS towards GOALS would be advantageous.

ID: 1956

The threshold requirements specified here in the MRD-IA are consistent with those from the GPRD-1fd. The goal requirements from the MRD-IA (called the objective requirements in the GPRD-1fd) may differ from those in the GPRD-1fd, reflecting acknowledged technical, scientific, cost or development time factors determined during the initial concept studies for the HES.

ID: 1957

Thus, the DS task is a THRESHOLD task. The SW/M task is a THRESHOLD task. The OO task is a GOAL task. The CW task is a THRESHOLD task. Within each THRESHOLD task, there are THRESHOLD and GOAL requirements. Within each GOAL task, there are THRESHOLD and GOAL requirements.

ID: 1958

The DS task will meet the following observational requirements detailed in the GPRD-1fd. It is critical to note that this information is included here is for reference only and provides traceability to the GPRD-1. The detailed requirements for the HES are detailed in subsections *after* this section. (See section 2.11.3 for relevant comments.) All parameters listed here are threshold values and may be exceeded to meet goal values. All parameters listed here are threshold values and may be exceeded to meet goal values. Goal values are currently listed in Appendix A.

ID: 1959

For reference, the distinction between "***measure***" and "***contribute to determinations of***" indicates whether the GPRD-1fd requirement is being fully met by a direct measurement performed by the instruments ("measure") or is being determined indirectly from measurements supplied in part or in whole by the instruments ("Contribute to determinations of").

ID: 1960

The DS task will ***contribute*** to the **Dust / Aerosol: Loading-CONUS** determinations. The DS task provides totaled vertical coverage over the CONUS to assist ABI in addressing the following details of the threshold requirement for the **Dust / Aerosol: Loading--CONUS**: over the 3000 km x 5000 km CONUS; with a threshold 15 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values integrated over the total column; contributing 5 km threshold mapping uncertainty (baseline); over the range of Light, Moderate, Heavy; and with TBD accuracy.

ID: 1961

The DS task will ***contribute*** to the **Dust / Aerosol: Loading-"Hemispheric"** determination to address the following details of the threshold requirement for the **Dust / Aerosol: Loading-"Hemispheric"**: over the

62 degree LZA disk; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values integrated over the total column; using 5 km threshold mapping uncertainty; over the range of Light, Moderate, Heavy; and with TBS accuracy.

ID: 1962

The DS task will ***contribute*** to the **Aircraft Icing Threat** determination to address the following details of the threshold requirement for the **Aircraft Icing Threat**: over the 62 degree LZA disk; with a threshold 60 minute refresh; with a 15 minute threshold latency; at 10 km threshold resolution, with 1 km top height resolution; using 5 km threshold mapping uncertainty; over the range of None - Heavy; and with 2 category accuracy.

ID: 1963

The DS task will ***contribute*** to **the Cloud Base Height: CONUS** determination to attempt to address the following details of the threshold requirement for the **Cloud Base Height: CONUS** over the 3000 km x 5000 km CONUS; contributing a threshold 60 minute refresh (baseline); with a 1 minute threshold latency; 10 km threshold resolution by using temperature and moisture profiles with 2 km vertical resolution; using 5 km threshold mapping uncertainty; over the range of 0-(TBS) km; and with 2.0 km cloud base accuracy.

ID: 1964

The DS task will ***contribute*** to **the Cloud Base Height: "Hemispheric"** determination to attempt to address the following details of the threshold requirement for the **Cloud Base Height: "Hemispheric"** over the 62 degree LZA disk; contributing a threshold 60 minute refresh (baseline); with a 1 minute threshold latency; contributing a 10 km threshold resolution by using temperature and moisture profiles with 2 km vertical resolution; using 5 km threshold mapping uncertainty; over the range of 0-(TBS) km; and with 2.0 km cloud base accuracy.

ID: 1965

The DS task will ***contribute*** to the **Cloud Layers/ Heights and Thickness: CONUS** determination along with ABI to attempt to address the following details of the threshold requirement for the **Cloud Layers/ Heights and Thickness: CONUS** over the 3000 km x 5000 km CONUS; contributing a threshold 60 minute refresh (baseline); with TBS vertical resolution; with a 15 minute threshold latency; at 10 km threshold resolution by using the radiance values; using 5 km threshold mapping uncertainty; over the measurement range of heights of 0-5 layers and thickness by general cloud type; and with TBS accuracy on thickness and height.

ID: 1966

The DS task will ***contribute*** to the **Cloud Layers/ Heights and Thickness: Hemispheric** determination along with ABI to address the following details of the threshold requirement for the **Cloud Layers/ Heights and Thickness: Hemispheric** over the 62 degree LZA disk; with a threshold 60 minute refresh; with TBS vertical resolution; with a 15 minute threshold latency; at 10 km threshold resolution by using the radiance values; with 2 km vertical accuracy; using 5 km threshold mapping uncertainty; over the measurement range of heights of 0-5 layers and thickness by general cloud type, and with TBS accuracy on thickness and height.

ID: 1967

The DS task will ***contribute*** to the **Cloud Particle Size Distribution: CONUS** determined indirectly by ABI by contributing background temperature and moisture fields.

ID: 1968

The DS task will ***contribute*** to the **Cloud Particle Size Distribution: Hemispheric** determined indirectly by ABI by contributing background temperature and moisture fields.

ID: 1969

Moved

ID: 1970

The DS task will ***contribute*** to the **Cloud Top Height: CONUS** determination along with ABI contributions to address the following details of the threshold requirement for the **Cloud Top Height: CONUS** over the 3000 km x 5000 km CONUS; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values; using 5 km threshold mapping uncertainty; with vertical resolution of surface to 500 mb: 0.3-0.5 km, 500 to 300 mb: 1-2 km; over then range of heights of 100m – 300 hPa; with measurement accuracy of surface to 500 mb: 0.3-0.5 km, 500 to 300 mb: 1-2 km.

ID: 1971

The DS task will ***contribute*** to the **Cloud Top Height: Hemispheric** determination along with ABI to address the following details of the threshold requirement for the **Cloud Top Height: Hemispheric** over the 62 degree LZA disk; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values; with vertical resolution of surface to 500 mb: 0.3-0.5 km, 500 to 300 mb: 1-2 km; using 5 km threshold mapping uncertainty; over then range of heights of 100m – 300 hPa; with measurement accuracy of surface to 500 mb: 0.3-0.5 km, 500 to 300 mb: 1-2 km.

ID: 1972

The DS task will ***contribute*** to the **Cloud Top Pressure: CONUS** determination along with ABI to address the following details of the threshold requirement for the **Cloud Top Pressure: CONUS** over the 3000 km x 5000 km CONUS; with a threshold 60 minute refresh; with a 10 minute threshold latency; at 10 km threshold resolution by using the radiance values; with vertical resolution of surface to 500 mb: 0.3-0.5 km, 500 to 300 mb: 1-2 km; using 5 km threshold mapping uncertainty; over then range of heights of 100m – 300 hPa; with measurement accuracy of surface to 500 mb: 0.3-0.5 km, 500 to 300 mb: 1-2 km.

ID: 1973

The DS task will ***contribute*** to the **Cloud Top Pressure: Hemispheric** determination with contributions from ABI to address the following details of the threshold requirement for the **Cloud Top Pressure: Hemispheric** over the 62 degree LZA disk; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values; with vertical resolution of surface to 500 mb: 0.3-0.5 km, 500 to 300 mb: 1-2 km; using 5 km threshold mapping uncertainty; over then range of heights of 100m – 300 hPa; with measurement accuracy of surface to 500 mb: 0.3-0.5 km, 500 to 300 mb: 1-2 km.

ID: 1974

The DS task will ***contribute*** to the **Cloud Top Temperature: Hemispheric** determined by ABI by contributing background temperature and moisture fields.

ID: 1975

The DS task will ***contribute*** to the **Cloud Type: CONUS** determined by ABI by contributing background temperature and moisture fields.

ID: 1976

The DS task will ***contribute*** to the **Cloud Type: Hemispheric** determined by ABI by contributing background temperature and moisture fields.

ID: 1977

The DS task will ***contribute*** to the **Turbulence: Hemispheric** determined by ABI by contributing background temperature and moisture fields.

ID: 1978

The DS task will ***contribute*** to **the Rainfall Potential** determination of ABI (and of the P^3I Microwave called GMS) by contributing background temperature and moisture fields.

ID: 1979

The DS task will ***measure*** the **Atmospheric Vertical Moisture Profile: CONUS** to address the following details of the threshold requirement for the **Atmospheric Vertical Moisture Profile: CONUS** over the 3000 km x 5000 km CONUS; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values; with vertical sampling from the surface to 500 mbar of 300 m to 500 m, from 500 to 300 mbar sampling 1-2 km, from 300 to 100 mbar sampling 1-2 km; using 5 km threshold mapping uncertainty; with 10% measurement accuracy from the surface to 500 mbar with 300 m to 500 m vertical sampling, 10% from 500 to 300 mbar with 1-2 km vertical sampling, and 20% from 300 to 100 mbar with 1-2 km vertical sampling. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute.

ID: 1980

The DS task will ***measure*** the **Atmospheric Vertical Moisture Profile: Hemispheric** to address the following details of the threshold requirement for the **Cloud Top Height: Hemispheric** over the 62 degree LZA disk; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values; with vertical sampling from the surface to 500 mbar of 300 m to 500 m, from 500 to 300 mbar sampling 1-2 km, from 300 to 100 mbar sampling 1-2 km; using 5 km threshold mapping uncertainty; a measurement range from 0-100%, with 10% measurement accuracy from the surface to 500 mbar with 300m to 500m vertical sampling, 10% from 500 to 300 mbar with 1-2 km vertical sampling, and 20% from 300 to 100 mbar with 1-2 km vertical sampling. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute in cloudy regions.

ID: 1981

The DS task will ***measure*** the **Atmospheric Vertical Temperature Profile: CONUS** to address the following details of the threshold requirement for the **Atmospheric Vertical Temperature Profile: CONUS** over the 3000 km x 5000 km CONUS; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values; with vertical sampling from the surface to 500 mbar of 300 m to 500 m, from 500 to 300 mbar sampling 1-2 km, from 300 to 100 mbar sampling 1-2 km, from 100 mbar and up with 2-3 km vertical sampling; with a measurement range of 180 - 320 K, using 5 km threshold mapping uncertainty; over the range of 180 to 320 K employing the following layering and precision: 0.3 to 0.5 km vertical sampling from the surface to 500 mbar, +/- 1 K from 500 to 300 mbar with 1-2 km vertical sampling, +/- 1K from 300 to 100 mbar with 1-2 km vertical sampling; and +/- 1K from 100 mbar and up with 2-3 km vertical sampling. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute.

ID: 1982

The DS task will ***measure*** the **Atmospheric Vertical Temperature Profile: Hemispheric** to address the following details of the threshold requirement for the **Atmospheric Vertical Temperature Profile: Hemispheric** over the 62 degree LZA disk; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values; using 5 km threshold mapping uncertainty; over the range of 180 to 320 K employing the following layering and precision: 0.3 to 0.5 km vertical sampling from the surface to 500 mbar, +/- 1 K from 500 to 300 mbar with 1-2 km vertical sampling, +/- 1K from 300 to 100 mbar with 1-2 km vertical sampling; and +/- 1K from 100 mbar and up with 2-3 km vertical sampling. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute in cloudy regions.

ID: 1983

The DS task will ***measure*** the **Capping Inversion Information: CONUS** to address the following details of the threshold requirement for the **Capping Inversion Information: CONUS** over the 3000 km x 5000 km CONUS; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values; using 5 km threshold mapping uncertainty; over the range of 210 to 300 K for T and Td and also surface to 650 mbar with 10 K accuracy for T and Td and height accuracy of 150-250 mbar. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute.

ID: 1984

The DS task will ***contribute*** to **the Derived Stability Indices: CONUS** determination of ABI by contributing background temperature and moisture fields.

ID: 1985

The DS task will ***contribute*** to the **Moisture Flux: CONUS** of HES and ABI to address the following details of the threshold requirement for the **Moisture Flux: CONUS** over the 3000 km x 5000 km CONUS; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values; vertical sampling of 0.3 to 0.5 km from the surface to 500 mbar, 1-2 km vertical sampling from 500 to 300 mbar, 1-2 km vertical sampling from 300 to 100 mbar; and 2-3 km vertical sampling from 100 mbar and up; using 5 km threshold mapping uncertainty; over the range of 0-20 g/kg/h; and with 10% accuracy. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute.

ID: 1986

The DS task will ***contribute*** to the **Moisture Flux: Hemispheric** of HES and ABI to address the following details of the threshold requirement for the **Moisture Flux: Hemispheric** over the 62 degree LZA disk; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values; using 5 km threshold mapping uncertainty; vertical sampling of 0.3 to 0.5 km from the surface to 500 mbar, 1-2 km vertical sampling from 500 to 300 mbar, 1-2 km vertical sampling from 300 to 100 mbar; and 2-3 km vertical sampling from100 mbar and up; over the range of 0-20 g/kg/h; and with 10% accuracy. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute.

ID: 1987

The DS task will ***contribute to*** the **Total Precipitable Water: Hemispheric** to address the following details of the threshold requirement for the **Total Precipitable Water: Hemispheric** over the 62 degree LZA disk; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values; using 5 km threshold mapping uncertainty over the range of 0-20 g/kg/h; and with 10% accuracy. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute in cloudy regions.

ID: 1988

The DS task will ***measure*** the **Total Water Content: CONUS** to address the following details of the threshold requirement for the **Total Water Content: CONUS** over the 3000 km x 5000 km CONUS; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values; using 5 km threshold mapping uncertainty; over the total vertical column; over the range of 0-100 mm; and with 1 mm precision. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute in cloudy regions.

ID: 1989

The DS task will ***measure*** the **Total Water Content: Hemispheric** to address the following details of the threshold requirement for the **Total Water Content: Hemispheric** over the 62 degree LZA disk; with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution by using the radiance values; using 5 km threshold mapping uncertainty; over the total vertical column; over the range of 0-100 mm; and with 1 mm precision. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute in cloudy regions.

ID: 1990

The DS task will ***contribute to*** the **Clear Sky Masks: CONUS** determinations for the DS task using the temperature from the HES-DS task to meet TBS requirements with accuracies of 10%.

ID: 1991

The DS task will ***contribute to*** the **Clear Sky Masks: Hemispheric** determinations for the DS task using the temperature from the HES-DS task to meet TBS requirements with accuracies of 10%.

ID: 1992

The DS task will ***measure*** the **Radiance: CONUS** to address the following details of the threshold requirement for the **Radiance: CONUS** over the 3000 km x 5000 km; with a threshold 60 minute refresh; with a 10 minute threshold latency; at 10 km threshold resolution by using the radiance values; using 5 km threshold mapping uncertainty; with vertical sampling and layering of 300-500 m from the surface - 500 mb, 1-2 km from 500-300 mb, 1-2 km from 300-100 mb, and 2-3 km from 100 mb and up; over the range of 180-320K (for visible and IR only); and with TBS accuracy. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute in cloudy regions.

ID: 1993

The DS task will ***measure*** the **Radiance: Hemispheric** to address the following details of the threshold requirement for the **Radiance: Hemispheric** over the 62 degree LZA disk; with a threshold 60 minute refresh; with a 60 minute threshold latency; at 10 km threshold resolution by using the radiance values;

using 5 km threshold mapping uncertainty; with vertical sampling and layering of 300-500 m from the surface -500 mb, 1-2 km from 500-300 mb, 1-2 km from 300-100 mb, and 2-3 km from 100 mb and up; over the range of 180-320 K (for visible and IR only); and with TBS accuracy. This measurement is <u>required only in clear and above cloud regions for this instrument</u>. A microwave instrument, if present, would also contribute in cloudy regions.

ID: 1994

The DS task will ***contribute to*** a determination of the **Upward Longwave Radiation: Surface/ CONUS** to address the following details of the threshold requirement for the **Upward Longwave Radiation: Surface/ CONUS** over the 3000 km x 5000 km; with a threshold 60 minute refresh; with a 60 minute threshold latency; at 25 km threshold resolution by using the radiance values; using 5 km threshold mapping uncertainty; over the range of 0-800 W/m^2; and with (TBS) accuracy.

ID: 5837

The DS task will ***contribute to*** a determination of the **Upward Longwave Radiation: Surface/ Hemispheric** to address the following details of the threshold requirement for the **Upward Longwave Radiation: Surface/ Hemispheric** over the 62 degree LZA; with a threshold 60 minute refresh; with a 60 minute threshold latency; at 100 km threshold resolution by using the radiance values; using (TBS) km threshold mapping uncertainty; over the range of TBS W/m^2; and with (TBS) accuracy.

ID: 1995

The DS task will ***contribute to*** a determination of the **Upward Longwave Radiation: TOA/ CONUS** to address the following details of the threshold requirement for the **Upward Longwave Radiation: TOA/ CONUS** over the 3000 km x 5000 km; with a threshold 60 minute refresh; with a 60 minute threshold latency; at 25 km threshold resolution by using the radiance values; using 5 km threshold mapping uncertainty; over the range of 0-500 W/m^2; and with (TBS) accuracy.

ID: 1996

The DS task will ***contribute to*** a determination of the **Upward Longwave Radiation: TOA/ Hemispheric** to address the following details of the threshold requirement for the **Upward Longwave Radiation: TOA/ Hemispheric** over the 62 degree LZA disk; with a threshold 6 hour refresh; with a 24 hour threshold latency; at 250 km threshold resolution by using the radiance values; contributing using 5 km threshold mapping uncertainty; over the range of 0-10 W/m^2; and with TBS accuracy.

ID: 1997

The DS task will ***measure*** **CO Concentration** to address the following details of the TBD threshold requirement for the **CO Concentration** over the 62 degree LZA disk; with a threshold 60 minute refresh (TBR); with a TBD minute threshold latency; at 50 km threshold resolution by using the radiance values; using TBR threshold mapping uncertainty; over the range of TBS; and with TBS accuracy.

ID: 1999

The DS task will ***measure*** **Ozone Layers: CONUS** to address the following details of the TBS threshold requirement for the **Ozone Layers: CONUS** over the 3000 km x 5000 km; with a threshold 60 minute refresh (TBS); with a 10 minute threshold latency; at 10 km threshold resolution by using the radiance values; using 5 km threshold mapping uncertainty; over the range of TBS; and with TBS accuracy.

ID: 2000

The DS task will ***measure*** **Ozone Layers: Hemispheric** to address the following details of the TBS threshold requirement for the **Ozone Layers: Hemispheric** over the 62 degree LZA disk; with a threshold 60 minute refresh (TBS); with a TBS minute threshold latency; at 10 km threshold resolution by using the radiance values; using TBS threshold mapping uncertainty; with a 3 km vertical resolution from 0-10 km and a TBS vertical resolution from 10-25 km, over the range of TBS; and with TBS accuracy.

ID: 2001

The DS task will ***contribute*** to the **Derived Motion Winds: CONUS** of ABI to supply background temperature and moisture fields.

ID: 2002

The DS task will ***contribute*** to the **Derived Motion Winds--Hemisphere** of ABI to supply background temperature and moisture fields.

ID: 6352

The DS task will *contribute to* determinations of **Microburst Windspeed Potential** in the atmosphere. ABI provides coverage over the CONUS to meet the following details of the threshold requirement for the **Microburst Windspeed Potential**: 10 km spatial resolution, 60 minute refresh rate, 5 km mapping accuracy, and 3 minute data latency need.

ID: 2003

The DS task will ***contribute*** to the **Flood Standing Water--Hemisphere** of ABI by supplying surface emissivity.

ID: 2004

The DS task will ***contribute*** to the **Land Surface (Skin) Temperature: CONUS** of ABI and HES by supplying surface emissivity.

ID: 2005

The DS task will ***contribute*** to the **Land Surface (Skin) Temperature: Hemispheric** of ABI and HES by supplying surface emissivity.

ID: 2006

The DS task will ***measure*** the **Surface Emissivity** to address the following details of the threshold requirements for the **Surface Emissivity** over the 3000 km x 5000 km CONUS; with a threshold 60 minute refresh (TBR); with a 60 minute threshold latency; at 10 km threshold resolution by using the radiance values; using 5 km threshold mapping uncertainty; over the range of 0.85 - 1.0; and with 0.05 accuracy.

ID: 2007

The SW/M task will meet the following observational requirements detailed in the GPRD-1fd. (See section 2.11.3 for relevant comments.) Goal values are currently listed in Appendix A.

ID: 2008

The SW/M task will *contribute to* **Volcanic Ash** in the atmosphere. HES-SW/M provides coverage over the full disk to attempt to meet the following details of the threshold requirement for the **Volcanic Ash**: 2 km spatial resolution, 15 minute refresh rate, 2 km vertical resolution on top height, a measurement range of 0-50 metric tons/km^2 with an accuracy of (TBS), 1.0 km mapping accuracy, and 1 minute data latency need.

ID: 2009

The SW/M task will ***contribute*** to **the Cloud Base Height: “Mesoscale”** determination to attempt to address the following details of the threshold requirement for the **Cloud Base Height: “Mesoscale”** over the 1000 km x 1000 km mesoscale; contributing a threshold 5 minute refresh (baseline); with a 1 minute threshold latency; contributing a 4 km threshold resolution by using temperature and moisture profiles with 2 km vertical resolution; using 2 km threshold mapping uncertainty; over the range of 0-(TBS) km; and with 2.0 km cloud base accuracy.

ID: 2010

The SW/M task will *measure* to the **Cloud Layers/ Heights and Thickness: CONUS** determination along with ABI to address the following details of the threshold requirement for the **Cloud Layers/ Heights and Thickness: CONUS** over the 5000 km x 3000 km; contributing a threshold 70 minute refresh; with a 15 minute threshold latency; contributing 4 km threshold resolution by using the radiance values; contributing 2 km threshold mapping uncertainty; over the range of heights contributions of 0-5 layers (TBS) and thickness by general cloud type, and with TBS accuracy on thickness and height.

ID: 5835

The SW/M task will *measure* the **Cloud Layers/ Heights and Thickness: Mesoscale** determination along with ABI to address the following details of the threshold requirement for the **Cloud Layers/ Heights and Thickness: Mesoscale** over the 1000 km x 1000 km; with a 5 minute refresh; with a 10 minute threshold latency; with 4 km threshold resolution by using the radiance values; with 2 km threshold mapping uncertainty; over the range of heights contributions of 0-5 layers (TBS) and thickness by general cloud type, and with TBS accuracy on thickness and height.

ID: 1969 (relocated)

The SW/M task will ***contribute*** to the **Cloud Particle Size Distribution--Mesoscale** determined indirectly by ABI by contributing background temperature and moisture fields.

ID: 2011

The SW/M task will *contribute* to the **Cloud Top Height: Mesoscale** determination along with ABI to address the following details of the threshold requirement for the **Cloud Top Height: Mesoscale** over 1000 km x 1000 km; contributing a threshold 5 minute refresh; with a 15 minute threshold latency; at 4 km threshold resolution by using the radiance values; with vertical resolution of surface to 500 mb: 0.3-0.5 km, 500 to 300 mb: 1-2 km; using 2 km threshold mapping uncertainty; over then range of heights of 0 – 20 km; with measurement accuracy of surface to 500 mb: 0.3-0.5 km, 500 to 300 mb: 1-2 km.

ID: 2012

The SW/M task will *contribute* to the **Cloud Top Temperature: Mesoscale** determined by ABI by contributing background temperature and moisture fields.

ID: 2013

The SW/M task will *contribute* to the **Cloud Type: Mesoscale** determined by ABI by contributing background temperature and moisture fields.

ID: 2014

The SW/M task will *contribute* to **the Convective Initiation** determination by ABI and HES by contributing necessary high spatial and temporal resolution background temperature and moisture fields.

ID: 2015

The SW/M task will *contribute* to **the Enhanced "V"/ Overshooting Top Detection: CONUS** determination of ABI and HES by contributing necessary high spatial and temporal resolution background temperature and moisture fields.

ID: 2016

The SW/M task will *contribute* to **the Enhanced "V"/ Overshooting Top Detection--Mesoscale** determination of ABI and HES by contributing necessary high spatial and temporal resolution background temperature and moisture fields.

ID: 2017

The SW/M task will *contribute* to the **Turbulence--Mesoscale** determination of ABI by contributing necessary high spatial and temporal resolution background temperature and moisture

ID: 2018

The SW/M task will *measure* the **Atmospheric Vertical Moisture Profile--Mesoscale** to address the following details of the threshold requirement for the **Atmospheric Vertical Moisture Profile--Mesoscale** over the 1000 km x 1000 km; with a threshold 5 minute refresh; with a 3 minute threshold latency; at 4 km threshold resolution by using the radiance values; using 2 km threshold mapping uncertainty; over the range of 0 - 100%; employing a measurement accuracy and a layering of 10% from the surface to 500 mbar with 300 m to 500 m vertical sampling, 10% from 500 to 300 mbar with 1-2 km vertical sampling, and 20% from 300 to 100 mbar with 1-2 km vertical sampling. This measurement is <u>required only in clear and above cloud regions for this instrument</u>. A microwave instrument, if present, would also contribute in cloudy regions.

ID: 2019

The SW/M task will *measure* the **Atmospheric Vertical Temperature Profile: Mesoscale** to address the following details of the threshold requirement for the **Atmospheric Vertical Temperature Profile: Mesoscale** over the 1000 km x 1000 km area; with a threshold 5 minute refresh; with a 3 minute threshold latency; at 4 km threshold resolution by using the radiance values; using 2 km threshold mapping uncertainty; over the range of 190 to 320 K employing the following layering and precision: 0.3 to 0.5 km vertical sampling from the surface to 500 mbar, +/- 1 K from 500 to 300 mbar with 1-2 km vertical sampling, +/- 1K from 300 to 100 mbar with 1-2 km vertical sampling; and +/- 1K from 100 mbar and up with 2-3 km vertical sampling. This measurement is <u>required only in clear and above cloud regions for this instrument</u>. A microwave instrument, if present, would also contribute in cloudy regions.

ID: 2020

The SW/M task will measure the **Capping Inversion Information--Mesoscale** to address the following details of the threshold requirement for the **Capping Inversion Information--Mesoscale** over the 1000 km x 1000 km; with a threshold 15 minute refresh; with a 3 minute threshold latency; at 4 km threshold resolution by using the radiance values; using 2 km threshold mapping uncertainty; over the delta temperature range of 0-20 K (TBS) with 0.5 K (TBS) accuracy. This measurement is <u>required only in</u>

clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute.

ID: 2021

The SW/M task will *contribute* to the **Derived Stability Indices--Mesoscale** of ABI by contributing background temperature and moisture fields.

ID: 2022

The SW/M task will *contribute* to the **Moisture Flux--Mesoscale** of HES and ABI to address the following details of the threshold requirement for the **Moisture Flux--Mesoscale** over the 1000 km x 1000 km; with a threshold 5 minute refresh; with a 3 minute threshold latency; at 4 km threshold resolution by using the radiance values; using 2 km threshold mapping uncertainty; vertical sampling of 0.3 to 0.5 km from the surface to 500 mbar, 1-2 km vertical sampling from 500 to 300 mbar, 1-2 km vertical sampling from 300 to 100 mbar; and 2-3 km vertical sampling from 100 mbar and up; over the range of 0-20 g/kg/hour (TBS); and with 10% accuracy (TBS). This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute.

ID: 2023

The SW/M task will *contribute* to the **Pressure Profile--Mesoscale** of HES if possible to address the following details of the threshold requirement for the **Pressure Profile--Mesoscale** over the 1000 km x 1000 km; with a threshold 15 minute refresh; employing the following vertical layering and precision: 0.3 to 0.5 km vertical sampling from the surface to 500 mbar, +/- 1 K from 500 to 300 mbar with 1-2 km vertical sampling, +/- 1K from 300 to 100 mbar with 1-2 km vertical sampling; and +/- 1K from 100 mbar and up with 2-3 km vertical sampling; with a 10 minute threshold latency; at 25 km threshold resolution by using the radiance values; using 10 km threshold mapping uncertainty; over the range of 10-1013 kPa; and with (TBS) accuracy. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute.

ID: 2024

The SW/M task will *contribute to* the **Total Water Content--Mesoscale** to address the following details of the threshold requirement for the **Total Water Content--Mesoscale** over the 1000 km x 1000 km; with a threshold 5 minute refresh; with a 5 minute threshold latency; at 4 km threshold resolution by using the radiance values; using 2 km threshold mapping uncertainty; over the total vertical column ; over the range of 0-100 mm; and with 1 mm precision. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute in cloudy regions.

ID: 2025

The SW/M task will *contribute to* the **Clear Sky Masks--CONUS** determinations for the SW/M task using the temperature from the HES-SW/M task to meet TBS requirements with accuracies of 10%.

ID: 2026

The SW/M task will *contribute to* the **Clear Sky Masks--Mesoscale** determinations of ABI for the SW/M task using the temperature from the HES-SW/M task with accuracies of 5-10%.

ID: 2027

The SW/M task will *measure* the **Radiance--Mesoscale** to address the following details of the threshold requirement for the **Radiance--Mesoscale** over the 1000 km x 1000 km; contributing a threshold 4.4 minute refresh (baseline) to meet the 60 minute requirement; contributing a 3 minute threshold latency (baseline) to meet the 30 minute requirement; at 4 km threshold resolution by using the radiance values;

using 2 km threshold mapping uncertainty; with vertical sampling and layering of 300-500 m from the surface -500 mb, 1-2 km from 500-300 mb, 1-2 km from 300-100 mb, and 2-3 km from 100 mb and up; over the range of 180-320K; and with TBS accuracy. This measurement is required only in clear and above cloud regions for this instrument. A microwave instrument, if present, would also contribute in cloudy regions.

ID: 2028

The SW/M task will *contribute* to the **Derived Motion Winds--Mesoscale** of ABI to supply background temperature and moisture fields.

ID: 2029

The SW/M task will *contribute* to the **Microburst winds** of ABI to supply background temperature and moisture fields.

ID: 2030

The SW/M task will *contribute* to the **Flood Standing Water--Mesoscale** of ABI by supplying surface emissivity.

ID: 2031

The OO task will meet the following observational requirements detailed in the GPRD-1FD. (See section 2.11.3 for relevant comments.) Goal values are currently listed in Appendix A.

ID: 2032

The OO task will *contribute to* determinations of the **Currents-Hemispheric** by ABI to address the following details of the threshold requirement for the **Currents---Hemispheric** over the full disk; with a threshold 6 hours refresh; with a 60 minute threshold latency; supporting 2 km threshold resolution of ABI by using the radiance values; using 1.0 km threshold mapping uncertainty; over the range of 0 – 5 m/sec (0 – 18 km/hour); and with 1.0 km/hour accuracy.

ID: 2033

The OO task will *contribute to* determinations of the **Currents---CONUS** by ABI to address the following details of the threshold requirement for the **Currents---CONUS** over the CONUS km; with a threshold 6 hours refresh; with a 60 minute threshold latency; supporting 2 km threshold resolution of ABI by using the radiance values; using 1.0 km threshold mapping uncertainty; over the range of 0 – 5 m/sec (0 – 18 km/hour); and with 1.0 km/hour accuracy.

ID: 2034

The OO task will *contribute to* determinations of the **Currents--Meososcale** by ABI to address the following details of the threshold requirement for the **Currents--Mesoscale** over the full disk; with a threshold 60 minute refresh; with a 30 minute threshold latency; at supporting 2 km threshold resolution of ABI by using the radiance values; using 1.0 km threshold mapping uncertainty; over the range of 0 – 5 m/sec (0 – 18 km/hour); and with 1.0 km/hour accuracy.

ID: 6356

The OO task will *contribute to* determinations of **Ocean Color: Offshore (Turbidity/Chlorophyll/ Reflectance) Turbidity--Hemispheric** in the 62 degree LZA to address the following details of the threshold requirement for the **Ocean Color: Offshore (Turbidity/Chlorophyll/ Reflectance) Turbidity—Hemispheric** over the 62 degree LZA: with a threshold TBS minute refresh; with a TBS minute threshold latency; at TBS km threshold resolution by using the radiance values; using TBS km threshold mapping uncertainty; over the range of TBS. The goal values are a 3 hour refresh, a 60 minute latency, at 4.0 km threshold resolution, over a total range (all TBSs) for water leaving radiances of 0.01-1 mW cm^{-2} μm^{-1} sr^{-1}, for Chlorophyll concentrations of 10^{-3} - 10^{2} microgram/liter, for Turbidity of 10^{-4} - 0.15 sr^{-1}m and reflectance of 10^{-4} - 0.15 sr^{-1}, 2.0 km mapping uncertainty, with a measurement accuracy of < 30%.

ID: 2035

The OO task will *contribute to* determinations of **Ocean Turbidity--Hemispheric** in the 62 degree LZA to address the following details of the threshold requirement for the Ocean Turbidity: with a threshold 3 hour refresh, a 60 minute latency, at 5.0 km threshold resolution, over a total range of 0 to -10 meters, 2.0 km mapping uncertainty, over the threshold range for 0-100 mg/m^3 with a measurement accuracy of < 30%.

ID: 2036

The OO task will *contribute to* the **Sea and Lake Ice Age -Hemispheric** determinations of ABI to address the following details of the threshold requirement for the **Sea and Lake Ice Age –Hemispheric** over the full disk: with a threshold TBS minute refresh; with a TBS minute threshold latency; at TBS km threshold resolution by using the radiance values; using TBS km threshold mapping uncertainty; over the range of TBS. The goal values are to distinguish between ice free, Nilas, Grey White, First year Medium, First year thick, Second year, and multiyear smooth and deformed ice with 1 km horizontal resolution, 1 km mapping uncertainty, with a threshold 3-hour refresh; a 15 minute latency.

ID: 2037

The CW task will meet the following observational requirements detailed in the GPRD-1FD (See section 2.11.3 for relevant comments.) Goal values are currently listed in Appendix A.

Note that the usage of "coastal" and "offshore" below together equate to the usage of coastal in the rest of this document.

ID: 2038

The CW task will *measure* the **Cloud Imagery: "Coastal"** determination of HES-CW together with ABI during the day and ABI at night to address the following details of the daytime threshold requirement for the **Cloud Imagery: "Coastal"**: over the US Navigable waters through the EEZ; with a threshold 60 minute refresh; with a 15 minute threshold latency; at 1 km threshold resolution by using imagery; using < / = 1 km threshold mapping uncertainty.

ID: 2039

The CW task will *contribute* to **Visibility: "Coastal"** determination of ABI by contributing background temperature and moisture fields to address the following details of the threshold requirement for the **Visibility: "Coastal"** over the US navigable waters though the EEZ; with a threshold 1-3 hour refresh; with a 15 minute threshold latency; at 3 km threshold resolution by using temperature and moisture profiles; using < 3 km threshold mapping uncertainty; over the range 0-10; and with 400 m accuracy.

ID: 2040

The CW task will *contribute to* the **Clear Sky Masks: CONUS** determinations for the CW task using the temperature from the HES-CW task to meet TBS requirements with accuracies of 10%.

ID: 2041

The CW task will *measure* the **Currents--Mesoscale** to address the following details of the threshold requirement for the **Currents--Mesoscale** over the 1000 km x 400 km; with a threshold 6 hours refresh; with a 60 minute threshold latency; at 2 km threshold resolution by using the radiance values; using 1.0 km threshold mapping uncertainty; over the range of 0-1.8 km/hour; and with 1.0 km/hour accuracy.

ID: 2042

The CW task will *contribute to* determinations of the **Currents: "Offshore" / CONUS** to address the following details of the threshold requirement for the **Currents: "Offshore" / CONUS** over the 1000 km x 400 km CONUS; with a threshold 3 hours refresh; with a 60 minute threshold latency; at 2 km threshold resolution by using the radiance values; using 1.0 km threshold mapping uncertainty; over the range of 0-1.8 km/hour; and with 1.0 km/hour accuracy.

ID: 2043

The CW task will *contribute to* determinations of **Ocean Color (Turbidity/Chlorophyll/Reflectance)-"Coastal"** in the coastal region (inside the EEZ) to address the following details of the threshold requirement for the **Ocean Color** (inside the EEZ): with a threshold 3-hour refresh, a 3-hour latency, at 0.3 km threshold resolution, 0.3 km mapping uncertainty, over the threshold range for water leaving radiances (all TBSs) of 0.01-1 mW cm^{-2} μm^{-1} sr^{-1}, for Chlorophyll concentrations of 10^{-3} - 10^{2} microgram/liter, for Turbidity of 10^{-4} - 0.15 $sr^{-1}m$ and reflectance of 10^{-4} - 0.15 sr^{-1}, with < 30% accuracy.

ID: 5839

The CW task will *contribute to* determinations of **Ocean Color (Turbidity/Chlorophyll/Reflectance)-"Offshore"** in the coastal region (inside the EEZ) to address the following details of the threshold requirement for the **Ocean Color** (inside the EEZ): with a threshold 24-hour refresh, a 1-hour latency, at 1.0 km threshold resolution, < 1.0 km mapping uncertainty, over the threshold range for water leaving radiances (all TBSs) of 0.01-1 mW cm^{-2} μm^{-1} sr^{-1}, for Chlorophyll concentrations of 10^{-3} - 10^{2} microgram/liter, for Turbidity of 10^{-4} - 0.15 $sr^{-1}m$ and reflectance of 10^{-4} - 0.15 sr^{-1}, with < 30% accuracy.

ID: 2044

The CW task will *contribute to* determinations of **Ocean Optical Properties -"Coastal" (**Particulate absorption, backscatter, fluorescence**)** in the coastal region (inside the EEZ) to address the following details of the threshold requirement for the **Ocean Optical Properties** (inside the EEZ): with a threshold 3-hour refresh; a 1-hour latency, at 0.3 km threshold resolution; 0.3 km mapping uncertainty; depth of (TBS), over the threshold ranges (all TBSs) of Absorption 0.01-10 m^{-1}, Scattering 0.01-50 m^{-1}, no Chlorophyll fluorescence, and with < 30% accuracy.

ID: 2045

The CW task will *contribute to* determinations of **Ocean Optical Properties -"Offshore" (**Particulate absorption, backscatter, fluorescence**)** (inside the EEZ) to address the following details of the threshold requirement for the **Ocean Optical Properties ---"Offshore"** (inside the EEZ): with a threshold 24-hour refresh; a 1 hour latency, at 1.0 km threshold resolution; 1.0 km mapping uncertainty; depth of (TBS); over the threshold ranges (all TBSs) of Absorption 0.01-10 m^{-1}, Scattering 0.01-50 m^{-1}, no Chlorophyll, and with < 30% accuracy.

ID: 2046

The CW task will *contribute to* determinations of the **Sea and Lake Ice Age -CONUS** of ABI in the coastal region (inside the EEZ) to address the following details of the threshold requirement for the **Ocean Optical Properties** (inside the EEZ): with a threshold 3-hour refresh; a 3-hour latency, at 2 km threshold resolution; 1.0 km mapping uncertainty; over the threshold age of 0-3 years with TBS accuracy.

ID: 2048

The CW task could *contribute to* determinations of the **Vegetation Fraction: Green** of ABI regionally, if tasked.

ID: 2049

The CW task could *contribute to* determinations of the **Vegetation Index--CONUS** of ABI regionally, if tasked.

ID: 2051

(2.10.2) 3.A. Top Priority Requirements

ID: 2052

The following two threshold requirements (3.A.1 and 3.A.2) are considered the highest priority improvements by the National Weather Service for the DS and SW/M tasks of the HES (although the priorities are also relevant to the environmental imaging tasks for the OO, and CW) relative to the GOES I-M series:

ID: 2053

(2.10.2) 3.A.1. Operation during eclipse and keep out zone periods

ID: 2054

The HES shall be capable of continuous operation during eclipse periods in geostationary orbit and shall meet all requirements except for navigation, where all navigation requirements are described in section (2.10.2) 3.B.15.1.

ID: 2055

The daily period of time prior to and following spacecraft eclipse and during the seasonal periods just prior to and after eclipse when sunlight impinges on the HES optical path(s) is commonly called the keep-out-zone period. The translation of these time periods to angular space results in the description of the operational zone, the restricted performance zone and the keep-out zone. The HES **shall** meet all of its operational requirements for all detector elements greater than the THRESHOLD limits shown here from the center of the uneclipsed sun. The HES should meet all of its operational requirements for all pixels greater than the GOAL limits shown here from the center of the uneclipsed sun. Outside of this limit lies the operational zone.

Channel	Outer Limit (THRESHOLD)	Outer Limit (GOAL)
Emitted IR bands (650-2720 cm^{-1}, 15.4 to 3.68 um)	10° (TBR)	5° (TBR)

Reflected Solar (0.4-3.0 um)	10° (TBR)	5° (TBR)
Low light	10° (TBR)	5° (TBR)

ID: 2073

The restricted performance zone lies between the outer limit in the table above and the inner limit of the table below. The HES **shall** meet all requirements, except the NEdN and On-Orbit calibration and accuracy, for all detector elements for the Threshold limits between the outer limit in the table above and the inner limit of the table below, as measured from the center of the uneclipsed sun. The HES should meet all requirements, except the NEDN and On-Orbit calibration and accuracy, for all detector elements for the GOAL limits between the outer limit in the table above and the inner limit of the table below, as measured from the center of the uneclipsed sun.

Channel	Inner Limit (THRESHOLD)	Inner Limit (GOAL)
Emitted IR bands (650-2720 cm^{-1}, 15.4 to 3.68 um)	3° (TBR)	2° (TBR)
Reflected Solar (0.4-3.0 um)	3° (TBR)	2° (TBR)
Low light	3° (TBR)	2° (TBR)

ID: 2091

Reflected solar (<3 microns) except for star sensing, are not applicable over the coverage area whenever any point on the coverage area falls within the Zone of Reduced Data Quality.

ID: 2092

In place of the NEdN, dynamic range, and On-Orbit calibration and accuracy sections, the HES shall meet the following requirements:

ID: 2093

- NEDN < 2x normal specification

ID: 2094

ID: 2095

ID: 2096

No detector shall saturate.

ID: 2097

The calibration performance shall degrade by no more that TBD (THRESHOLD) and 0.5 K (Goal).

ID: 2098

Discussion: Geostationary viewing geometry results in sunlight impingement on the optical path of the GOES HES telescope(s) during the periods of the year several weeks around each equinox. When this happens, stray sunlight may cause a degradation of the radiometric response accuracy of the sounder's Earth-viewing detectors, as well as heating of the telescope(s). How much degradation and how long this effect lasts will depend on many design features of the HES. The HES should be designed in such a way that intrusion of sunlight from outside the field of view is minimized, reducing as much as is practical the need for "keep-out zones" near local midnight during the equinoxes, and in addition minimize heating of telescope(s) mirrors and mounts. Ground operations maintain a prohibition against scanning within 1.4 (TBR) degrees of the sun center under routine operating conditions to prevent HES instrument damage. Focused sunlight on the optics is a cause of potential damage. The energy is sufficient to damage optical materials and coatings, and to irreparably damage detectors. Any detector within 3 degrees of the sun (TBR) is not required to provide useful data. The relaxation of requirements between 3 (TBR) and 10 (TBR) degrees of the sun threshold (between 2 (TBR) and 5 (TBR) degrees goal) is done in recognition that stray light will degrade performance in the local midnight condition. A JPL February 2000 report ("Keep-Out Zone Specification for the Advanced Baseline Imager and Background Discussion,") has documented the initial numbers used in this requirement.

ID: 2099

Benefits: There is a need for near-continuous coverage for IR data, including both spring severe weather and fall hurricane seasons.

ID: 2100

(2.10.2) 3.A.2. Improve DS task spatial coverage (and addition of other coverage tasks).

ID: 2101

The instrument performing the DS task shall produce data (while meeting all on-orbit calibration and navigation requirements) with the coverage rate specified below:

ID: 2102

ID: 2103

Figure 1. Shown are the approximate areas of 62 degrees local zenith angle from both the GOES-East and GOES-West sub-satellite points. The threshold coverage rate calls for the region within the 62-degree arc, excluding half of the overlap region, to be scanned each hour. For information only, an image for one hour of the infrared window from the current generation instruments is shown. The 62-degree local zenith angle (LZA) coverage for the DS task is about 5 times larger than the coverage from the current generation sounder over the same period.

ID: 2104

a) Scan the region within 62-degrees local zenith angle (although only scan half of the region of overlap between the eastern and western satellites, nominally at 105W) within one hour (see Figure 1). (THRESHOLD) For the threshold resolution for this task of 10 km, as discussed in section (2.10.2) 3.B.2.d, an associated ground sample rate (GSR) providing nominally constant noise performance can be defined. It is the coverage rate just discussed R_{cov} divided by (A_{pix}*ε_{scan}) where A_{pix} is the product pixel area and εscan is the scan efficiency which includes overlap to avoid gaps, image rotation, number of calibrations needed during the scan, and step and settle limitations of the scan mirror. With R_{cov} = 2.0e4 km2/sec, the threshold GSR shall be 195 (TBR), defined with a scan efficiency of 1.0. For the same parameters and an ε_{scan}=0.8, the sensor GSR will be 240 Hz (TBR) to achieve the 195 Hz GSR requirement.

ID: 2105

Scan the full earth disk in one hour (GOAL) which implies a ground sample rate of 272 Hz (TBR) for the 10 km spatial sample, defined with a scan efficiency of 1.0. For the same parameters and an ε_{scan}=0.8, the sensor GSR will be 340 Hz (TBR) to achieve the 272 Hz GSR requirement. If a finer spatial resolution is employed to approach the goal of that requirement, a smaller A_{pix} results which can be compared against the goal GSR expressed as 27000/A_{pix}.

ID: 2106

c) The scan area shall be selectable to offer flexible scan scenarios. This ranges from mesoscale areas (1000 km by 1000 km) through the size of the full disk, using the 62 degree LZA ground sample rate described in item a in this list. If the DS task is performed by a separate instrument than the instrument performing the SW/M task, then the instrument performing the DS task must still offer flexible scan scenarios for backup purposes, although the instrument performing the SW/M task will provide the 1000 km x 1000 km coverage (THRESHOLD). If the same instrument performs the DS and SW/M tasks, the scan efficiencies discussed in a above may be slightly different, but the ground sample rate is an instrument capability for noise performance that will apply to both.

ID: 2107

ID: 2108

d) Overall task efficiency bearing on the DS task:

ID: 2109

As a THRESHOLD the DS task instrument(s) **shall** continuously perform either a DS scan *or* a SW/M scan.

ID: 2111

As a GOAL, the sounding task instrument(s) <u>should</u> be capable of continuously and concurrently performing both a DS scan *and* a SW/M scan.

ID: 2112

The instrument performing the SW/M task shall produce data (<u>while meeting all on-orbit calibration and navigation requirements</u>) with the coverage specified below:

ID: 2113

Mesoscale (1000 km x 1000 km) sounding coverage in 4.4 (TBR) minutes (THRESHOLD) and a refresh rate of 4.4 (TBR) minutes. If a CONUS-sized area of 5000 km x 3000 km were selected, the refresh rate for this area would therefore be 15 times longer at 66 minutes (TBR). This task will be performed subsequently to any other pre-assigned tasks of this instrument.

ID: 2114

Mesoscale (1000 km x 1000 km) sounding coverage in 2 (TBR) minutes (GOAL) with a refresh rate of 2 (TBR) minutes (TBR) in addition to meeting its other pre-assigned tasks.

ID: 2115

Mesoscale (1000 km x 1000 km) images (GOAL) in the visible band and near 11.2 um with 30 second refresh.

ID: 2116

The scan area shall be selectable and flexible.

If the SW/M task is not performed by the same instrument as that performing the DS task, a larger value for the ground coverage rate for the SW/M sounding task may be realizable.

ID: 2117

e) Overall task efficiency bearing on the SW/M task:

ID: 2118

As a THRESHOLD the SW/M task instrument(s) shall continuously perform either a DS scan *or* a SW/M scan.

ID: 2119

The time to switch between HES sounding tasks shall be 25 (TBR) seconds or less. (Under review)

ID: 2120

As a GOAL, the sounding task instrument(s) <u>should</u> be capable of continuously and concurrently performing both a DS scan *and* a SW/M scan.

ID: 2121

The instrument performing the OO task shall produce data (<u>while meeting all on-orbit calibration and navigation requirements</u>) with the coverage specified below:

ID: 2122

a. Coverage of open ocean area lying within the 62 degree LZA, which is approximately 6.8e7 km (TBR) in 3 hours TBR (THRESHOLD) in addition to meeting its other pre-assigned tasks. This meets the most restrictive THRESHOLD time requirement from the GPRD-1fd for offshore currents.

ID: 2123

Coverage of open ocean area lying within the 62 degree LZA, which is approximately 6.8e7 km^2 (TBR) in hour (GOAL) in addition to meeting its other pre-assigned tasks. This meets the most restrictive GOAL time requirements from the GPRD-1fd for offshore currents.

ID: 2124

The scan area shall be selectable to offer flexible scan scenarios.

ID: 2125

The instrument performing the CW task shall produce data (<u>while meeting all on-orbit calibration and navigation requirements</u>) with the coverage specified below:

ID: 2126

400 km wide (~22.22 km of the territorial sea originating at the low tide water line and the additional 370.4 km from the outer edge of the territorial sea to the to the Exclusive Economic Zone) along the length of the coast (US east and gulf coasts ~6000 km, US west coast and Hawaii ~3300 km totaling ~2.4e6 km^2 (TBR) when including the 400 km width) in 3 hours TBR (THRESHOLD) in addition to meeting its other pre-assigned tasks. This meets the most restrictive THRESHOLD time requirement from the GPRD-1fd for coastal currents.

ID: 2127

Coverage area specified above (in item 2126) in 60 minutes. This meets the most restrictive GOAL time requirement from the GPRD-1fd for coastal currents.

ID: 2128

The scan area shall be selectable to offer flexible scan scenarios, including 1) a 1200 km x 1200 km area ("HES localized mode 570" nm, under study) within CONUS that is observed primarily outside HEW-CW observing times and 2) a 400 km x 400 km area ("HES localized mode").

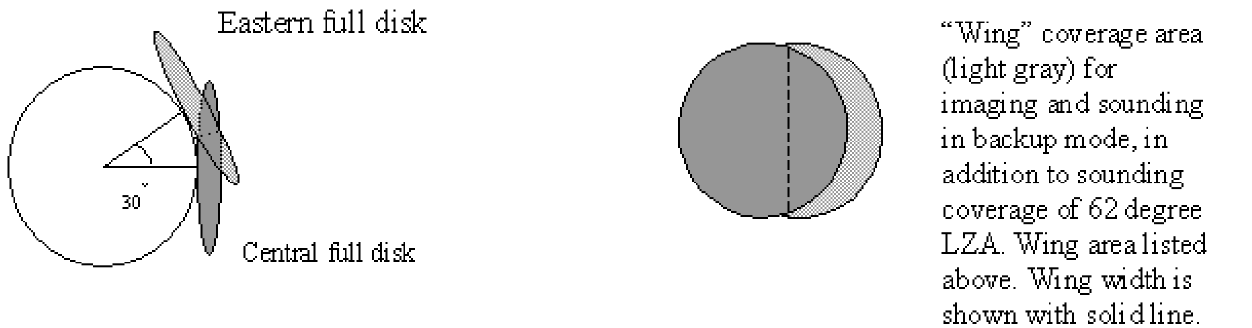
ID: 2129

As a THRESHOLD, the CW task instrument(s) shall continuously perform CW scans by executing on of its modes (i.e. as defined in ID 2121). Continuously implies that the coverage rate will be met.

ID: 2130

ABI Backup mode (HES THRESHOLD across all tasks) (TBR): If ABI fails, HES must provide a backup, albeit with degraded capability compared to ABI. Images will be produced within a period of 30 minutes or less from the area of either the western or eastern full disk view that is not covered by a central full disk view (nominally 1.91e7 km^2 as shown in Figure 1a and known as the “wing” with a maximum width of 2806 km). The spatial resolution shall be no coarser that 4 km in the IR and 1 km in the visible.

Soundings over the 62-degree LZA shall meet all requirements of the DS task (TBR) except the NEdN, which will be what the vendor can provide. “What the vendor can provide” shall include the subset of ABI band coverage in the visible band, reflected solar < 1 um (or reflective solar < 3 um), as well as the



ID: 2131

Figure 1a. (Left) Polar view of earth showing eastern full disk coverage and central full disk coverage in a failure scenario for the western A satellite in the distributed architecture. (Right) Equatorial view of ABI coverage from central disk and HES backup mode coverage (or “wing” coverage) from the eastern satellite.

ID: 2132

Discussion: The THRESHOLD requirement does not mean the operational schedule for the instrument assigned to the DS task will simply consist of sequential nearly full disk “sounding” images. It does set a threshold ground sample rate for this instrument of 62 degrees local zenith angle in one hour including all on-board calibration and navigation, which will afford a coverage rate than can be used to make non-full disk observations. (Because the ground sample rate can also be understood in terms of nominally constant noise performance, it is helpful in understanding that moving to smaller pixels that the threshold DS value lead to smaller coverage areas as a consequence of the longer associated integration time.) The CONtinental United States (CONUS) area (defined approximately as the geographic area encompassing 10N-60N latitude and 60W-125W longitude), or the equivalent of a nadir-viewed rectangle 5000x3000 kilometers in dimension may be scanned more frequently, allowing more clear observations as clouds move. Clear observations yield better retrievals but there is interest in retrievals in the air over clouds. Southern Hemisphere oceanic regions may be scanned less frequently, which would allow observations over large regions without conventional observations (i.e., the Pacific Ocean). *If the SW/M task is met with a separate instrument than that performing the DS task, then the instrument providing the DS task will concentrate on the 62-degree disk to support global modeling.*

ID: 2133

At this point, the full impact of the faster full disk coverage performance goal of one hour on the advanced sounder design and requisite technologies may be a system driver. NOAA/NESDIS, with NASA, continues to guide engineering studies at FFRDCs (Federally Funded Research and Development Centers) to explore advanced HES design and concepts directed at faster coverage rates. The threshold-scanning requirement is somewhat more than 2½ times faster than the coverage rate of the 5000 km x 3000 km per half hour of the first HES (formerly the first ABS) design. The coverage rate of 62-degree local zenith angle in one hour represents at least a factor of five increase over that of the current filter wheel sounder. The thrust of NOAA's NWS sounder scanning needs is to cover both CONUS and large coastal and open ocean areas, particularly in the Pacific. Tropical cyclone coverage is needed as well. The major technology areas to be explored for the increased coverage rate are: increased aperture size, increased number of detectors and focal plane array (FPA) size, and mechanical cooling for an operational instrument. Increased coverage rates directly impact NEdN, A/D converter requirements, and data rates.

ID: 2134

Current WMO guidance calls for an *optimum* repeat cycle of one hour of sounder coverage for global Numerical Weather Prediction (NWP). The faster end of their median range (one level down from optimal) is 2.3 hours.**

ID: 2135

Over the next decade, national-domain NWP models will move from an age where many of the physical processes simulated by the models were approximated statistically and the resolution of the forecast models was notably *coarser* than that of geostationary soundings and into an era when most of the physical processes in the models will be treated explicitly and at a resolution *finer* than that of the current generation of satellite observations. For example, the Nested Grid Model was implemented in 1986 with a horizontal resolution of 85 km; the current Eta model has 12 km horizontal resolution as of May 2002. This resolution will be approximately nine times finer than the resolution available from the current GOES -I/M and GOES-N/Q sounders. By 2010, the resolution of national domain NWP models will approach 5 km and the models will likely be non-hydrostatic. These models will require higher-space and time-resolution observations and can use these higher-resolution data in new ways (e.g., specifying cloud droplet distributions). Continued improvements in NWP model resolution will occur thereafter, necessitating even higher resolution data as input. Global models by comparison are anticipated to have about 35 km spatial resolution in 2010. This is part of the motivation to list the SW/M tasks separately from that of the DS task. (It should be noted that each halving of grid spacing requires over a 10-fold increase in computer power. The expected model resolution improvements are consistent in direction with the increases in computing power predicted by industry during this period, although not as rapid due to the increases in detail associated with improvements in parameterization.)

ID: 2136

The mesoscale data supporting these forecast systems will come primarily from two operational observing systems, doppler radar and geostationary satellites. While the doppler radar will provide 1-2 km resolution precipitation and wind information *after* clouds are already present, the geostationary sounders will be the primary source of localized moisture and temperature (stability) data in clear air *before* the storms develop, as well as information about cloud top structures. These data sets provide natural complements to each other. For example, it has been shown that non-hydrostatic models can do credible jobs of forecasting the short-range evolution of convective systems once they are mature enough to be detected by doppler radar. However, satellite depictions of rapidly changing low-level moisture and stability patterns will be critical in determining the timing and location of the onset of localized convection. This is the motivation for calling out the SW/M as a separate task to sample the clear air in advance of the storm formation. Since the sounder data set and the doppler radar data sets will be used in concert, in the long-term they must be of consistent spatial resolution over the CONUS since this is where the doppler radar exists.

ID: 2137

Although the initial, minimal "Threshold" requirements for independent, 10-km, geostationary moisture and temperature observations are of approximately the same order of magnitude as the expected model resolution in 2010, some features that will be already included in the forecast model at that time may already start to be under-represented in the satellite data. For example, strong low-moisture gradients produced across several kilometers by local variations in antecedent precipitation produced by the model's surface evaporation systems could begin to appear overly smoothed in the 10-km satellite data. Similarly, the structures of clouds being forecast to cover 3 or 4 grid boxes by the model and observed by the GOES imager could be unresolved by the high-spectral resolution instrument meeting the DS task. The SW/M task consequently has improved spatial resolution.

ID: 2138

As model resolution and physical realism continue to increase beyond 2010, the impact of the geostationary sounder data from a "threshold system" performing the DS task only will diminish unless the resolution of the observations keeps pace with the increased model resolution and approaches that of the complementary radar data sets, which is addressed when the SW/M task is met. These higher-resolution satellite sounding data will become increasingly critical in improving forecasts of the timing and location of the onset of hazardous weather events ranging from severe convection to localized heavy icing. For example, soundings obtained in the small areas between developing cumulus clouds will be needed to provide a continuous detailed picture of upstream moisture and stability patterns for forecasting and nowcasting systems, as well as direct forecaster use. To obtain the kinds of observations that assure continued impact of geostationary sounder data beyond 2020, the documented NOAA's NWS performance Threshold task of SW/M, at the goal spatial resolution of the DS task, is desirable as soon as technically and financially feasible in order to assure an evolutionary observing system improvement path that continually incorporates technological advances which support NOAA's NWS forecast improvement goals at minimal cost.

ID: 2139

Benefits: This spatial coverage rate allows for generation of the satellite radiances and products frequently over the CONUS region for forecasters and regional numerical models, plus allowing greater oceanic coverage for assimilation into global numerical models. Benefits of improved spatial resolution are discussed above as well as in section (2.10.2) 3.B.2.d.

ID: 2140

(2.10.2) 3.B. Additional HES Requirements

ID: 2141

Table 1 describes the retrieval accuracy required from the DS task and SW/M Sounding task for information only, and to tie to NOAA's NWS requirements. Note that 1) the vertical resolution listed by NOAA's NWS reflects vertical sampling 2) the "100 hPa and above" listed below by NWS is essentially to 1 hPa and 3) there is an interest in soundings in air above the clouds and consequently the retrievals from such a region may be impacted by additional uncertainties from cloud signal interaction.

ID: 2142

This MRD ties instrument requirements to these retrieval accuracies. Radiances are described in subsequent sections of this document. The need for all weather soundings will be partially addressed by a microwave instrument that is P^3I for GOES-R and partially addressed for sounding from the HES. For the HES, there is an interest in soundings in air above the clouds and consequently the retrievals from such a region may be impacted by additional uncertainties from cloud signal interaction. The NEdN values listed later in this document reflect noise performance in clear air conditions only. Goal NEdN values in the shortwave infrared have also been listed to address sounding in the presence of partial cloud cover.

ID: 2143

Tables 2a, 2b, 2 c, 2d, and 2e area partial summary, for convenience, of the THRESHOLD requirements for the DS, SW/M, OO and CW tasks respectively. More detail can be found on each of these topics in the corresponding sections of the document.

ID: 5430

Table 1. Sounding Performance Summary: Accuracies and vertical "resolution" in clear air *provided for information only*. See note above for important clarifications for this table.

Altitude Range	Observational Accuracy		Observational Accuracy		Vertical Resolution	
	Temperature THRESHOLD	Temperature GOAL	Humidity THRESHOLD	Humidity GOAL	THRESHOLD	GOAL
Surface - 300 hPa	+/-1.0 K	+/- 0.5 K	+/- 10%	+/- 5%	Surface-500 hPa; 0.3-0.5 km layers 500 - 300 hPa 1 - 2 km layers	Surface-500 hPa; < 0.3 - 0.5 km layers, 500-300 hPa; < 1-2km layers
300 hPa - 100 hPa	+/- 1.0 K	+/- 0.5 K	+/- 20%	+/- 10%	1 - 2 km layers	< 1 - 2 km layers
100 hPa and above	+/- 1.0 K	+/- 0.5 K	N/A	N/A	2 - 3 km layers	< 2 - 3 km layers

ID: 5469

Table 2a. HES DS Task Observational Requirements Parameters Summary (Partial List)

Requirement and Source		Threshold
Spatial resolution*	Visible	1 km IFOV on a centroid to centroid distance of 1 km (see 3.B.2.d) to enable cloud-cover detection including low-light situations
	IR	10 km on a centroid to centroid distance of 10 km (280 urad (THRESHOLD), 2 km on a centroid to centroid distance of 2 km (GOAL) (see 3.B.2.d)
Detector-Optics Ensquared energy (all bands)**		See 3.B.2.e and Table 3c. and Table 3d. therein
Spatial coverage rate	The region within 62 degrees local zenith angle (except only half of the overlap region between two satellites) (Figure 1)	Each hour, including any necessary allowance for IR calibration and navigation Operational scenarios may deviate from scanning the 62 degree LZA every hour, but this coverage rate is needed to provide both CONUS and a minimum adequate level of atmospheric coverage over the data sparse oceans
	Regional and Mesoscale when required	Must be supported and selectable
Operation during eclipse*		Yes
Timeliness of data*	Radiance	3 minutes (Threshold), 1 minute (goal),
Simultaneity*		Within 10 sec. for all bands at any FOV (THRESHOLD); within 5 sec. (GOAL) (Limits cloud encroachment in FOV)
Pixel to pixel Simultaneity		Within 6 minutes for all adjacent pixels when covering 62 degree local zenith angle and within 3 minutes when covering a CONUS-sized area (THRESHOLD)
IR Spectral bands and spectral resolution, Radiometric Sensitivity, Dynamic Range**		(Tables 4a, 4aa, 4b, 6a. and 6b.)
Registration within frame* (adjacent pixels)		<= 0.5 IR IFOV at SSP (THRESHOLD); <= 0.25 IR IFOV at SSP (GOAL)
IR band linearity		See 3.B.2.j
Band to band co-registration	Visible-IR	<= 1.0 km (<= 28 urad
	IR-IR*	< 25% of IFOV (THRESHOLD) and < 10% of IFOV (GOAL)
On-orbit calibration	Visible	See 3.B.12
	IR	See 3.B.13
Lifetime***	Ground storage	5 years TBR
	On-orbit storage	5 years TBR is maximum possible
	Mean Mission Duration (MMD) life	8.4 year MMD (see section 3.B.1) TBR

	(MMD) life	
	Instrument On Life	10 years at R=0.6 (see section 3.B.1)

ID: 5547

Table 2b. HES SW/M Task Observational Requirements Parameters Summary (Partial List)

Requirement and Source		Threshold
Spatial resolution *	Visible	1 km IFOV to enable cloud-cover detection including low-light situations
	IR	4 km on a 4 km centroid to centroid distance (THRESHOLD); 2 km on a 2 km centroid to centroid distance (GOAL) (see 3.B.2.d)
Detector-Optics Ensquared energy (all bands)**		See 3.B.2.e and Tables 3c. and 3d. therein
Spatial coverage rate	1000 km x 1000 km region	Each 4.4 minutes, including any necessary allowance for IR calibration and navigation Operational scenarios may deviate from scanning a 1000x 1000 region, but this coverage rate is needed to provide both CONUS and a specified for sufficient mesoscale performance at high resolution
	Smaller and larger regions	Must be supported and selectable
Operation during eclipse*		Yes
Timeliness of data*	Radiance	3 minutes (threshold) and 1 minute (goal)
Simultaneity*		Within 10 sec. for all bands at any FOV (THRESHOLD); within 5 sec. (GOAL) (Limits cloud encroachment in FOV)
Pixel to pixel Simultaneity		Within 6 minutes for all adjacent pixels when covering 62 degree local zenith angle and within 3 minutes when covering a CONUS-sized area (THRESHOLD)
IR Spectral Bands and Spectral Resolution Radiometric Sensitivity Dynamic Range,		(Tables 4a, 4aa, 4b (rev), 6c. and 6d.)
Registration within frame (adjacent pixel)*		<= 0.5 IR IFOV at SSP (THRESHOLD); 0.25 IR IFOV at SSP (GOAL)
IR band linearity		See 3.B.2.j
Band to band co-registration	Visible-IR	<=1.0 km (<=28 urad
	IR-IR*	< 25% of IFOV (THRESHOLD) and < 10% of IFOV (GOAL)

On-orbit calibration	Visible	See 3.B.12
Lifetime***	Ground storage	5 years TBR
	On-orbit storage	5 years TBR is max possible
	Mean Mission Duration (MMD)	8.4 year (see section 3.B.1) TBR
	Instrument On Life	10 years at R=0.6 (see section 3.B.1)

ID: 5605

Table 2c. HES OO Task Observational Requirements Parameters Summary (Partial List)

Requirement and Source		Threshold
Spatial resolution*	Reflected solar	4.0 km TBR on a centric to centric distance of 4.0 km (THRESHOLD) 1.0 km on a centric to centric distance of 1.0 km (GOAL) (see 3.B.2.d)
Modulation Transfer Function (all bands)		See 3.B.2.e and Table 3.e. Therein
Spatial coverage rate	Open ocean area lying within the 62 degree LZA	Open ocean area lying within the 62 degree LZA in 3 hours (~6.8e7 km^2) (TBR)
	Regional and Mesoscale when required	Must be supported and selectable
Operation during eclipse*		Yes
Timeliness of data	Radiance	15 (TBR) minutes (THRESHOLD) (goal), 5 (TBR) minutes (GOAL)
Simultaneity*		Within 30 (TBR) sec. for all bands at any FOV (THRESHOLD); within 20 sec (GOAL)
Pixel to pixel Simultaneity		Within TBD minutes for all adjacent pixels (THRESHOLD)
IR Spectral bands and spectral resolution Radiometric Sensitivity Dynamic Range**		(Tables 4c and 6e.)
Registration within frame (adjacent pixels)		<= 0.5 IFOV (<= 56 urad at SSP (THRESHOLD); <= 0.25 IFOV (288 urad at SSP (GOAL)
Reflected solar band linearity		See 3.B.2.j
Band to band co-registration	Reflected solar	<= 0.5 IFOV at SSP (THRESHOLD) or 2.0 km at SSP; <= 0.25 IFOV at SSP or 1.0 km at SSP (GOAL);
On-orbit calibration	Reflected solar	(see 3.B.14)
Lifetime***	Ground storage	5 years TBR

	On-orbit storage	5 years TBR is max possible
	Mean Mission Duration (MMD)	8.4 year (see section 3.B.1) TBR
	Instrument On Life	10 years at R=0.6 (see section 3.B.1)

ID: 5671

Table 2d. HES CW Task Observational Requirements Parameters Summary (Partial List)

Requirement and Source		Threshold
Spatial resolution*	Reflected solar	0.3 km TBR on a centroid to centroid distance of 0.3 km (THRESHOLD) for wavelengths< 1.0 um and 1.2 km on a centroid distance of 1.2 km for wavelengths >/ = 1 um; 0.15 km on a centroid to centroid distance of 0.15 km (GOAL)
	IR (GOAL)	2.0 km TBR on a centroid to centroid distance of 2.0 km (THRESHOLD); 1.0 km on a centroid to centroid distance of 1.0 km (GOAL)
Modulation Transfer Function (all bands)		See 3.B.2.e and Tables 3f1, 3f2, and 3f3. therein
Spatial coverage rate	Coastal coverage along the length of the coast (US east and gulf coast: ~6000 km, US west coast ~2100 km) by ~400 km in width	Coastal coverage along length of coast (US east and gulf coast: ~6000 km (totaling ~ 2.4e6 km^2) in width in 3 hours (TBR)
	Regional and Mesoscale when required	Must be supported and selectable
Operation during eclipse*		Yes
Timeliness of data*	Radiance	15 minute (THRESHOLD), 5 minute (goal)
Simultaneity*		Within 15 sec. for all bands at any FOV (THRESHOLD); within 10 sec. (GOAL)
Pixel to pixel Simultaneity (threshold)		Within 10 minutes (TBR) for all adjacent pixels (THRESHOLD), TBD (GOAL)
IR Spectral bands and spectral resolution Radiometric Sensitivity Dynamic Range***		(Tables 4d and 6f.)
Registration within frame (adjacent pixels)		<= 1.0 IFOV at SSP (THRESHOLD) for 300 m max at SSP 0.83 IFOV at SSP (GOAL) for 250 m max at SSP
Reflected solar band linearity		See 3.B.2.j
Band to band co-	Within Reflected-solar	<= 0.3 km (<= 9 mrad) at SSP (THRESHOLD); 0.25

registration	region	km (7 mrad) at SSP (GOAL)
	Reflected solar -IR	For reflected solar < 1 um: <= 0.25 IR IFOV at SSP (THRESHOLD) or 0.3 km at SSP; <= 0.10 IFOV at SSP or 0.25 km at SSP (GOAL)
On-orbit calibration	Reflected solar	See 3.B.14
	IR	See 3.B.13
Lifetime***	Ground storage	5 years TBR
	On-orbit storage	5 years TBR is max possible
	Mean Mission Duration (MMD)	8.4 years (see section 3.B.1) TBR
	Instrument On Life	10 years with R=0.6 (see section 3.B.1)

ID: 2194

(2.10.2) 3.B.1. Lifetime

ID: 2195

The instrument shall be designed for an 8.4 year Mean Mission Duration (MMD). A 10 year instrument-on life shall be supported with Reliability (R) of 0.6. The MMD is the integrated area under the instrument reliability versus time curve.

ID: 2196

Discussion: NOAA-NESDIS studied the benefits of extending the present lifetime of the current GOES series, as well as issues associated with extending the lifetime as a way to contain and reduce program costs. Given that new instruments are required to meet NWS requirements as well as provide replacements and new designs, it was timely to look at the longer life. However, long life may be traded against the insertion of new capabilities and/or technologies. Major long lifetime issues would be: Avoiding single point failure designs, long life evaluation through accelerated lifetime testing of selected components such as mechanisms, thermal control of optics and electronics, analyses such as FMECA (Failure Mode, Effects and Criticality Analysis). **

ID: 2197

Benefits: Extending the lifetime will save money by reducing program costs.

ID: 2198

(2.10.2) 3.B.2. Types of observations and accuracies

ID: 2199

The HES must yield spectral radiance observations suitable for retrieval of temperature and relative humidity over a three-dimensional set of reporting intervals defined below. The vertical observations will be retrieved from measured radiances over a two-dimensional grid defined as horizontal cells.

ID: 2200

(2.10.2) 3.B.2.a) Soundings

ID: 2201

These refer to retrieved profiles of atmospheric temperature and humidity as defined below. Note that it is not the intention of this document to specify sounding algorithms, but rather to specify radiometric performance determined in Phase-A studies to be sufficient to meet the observational requirements of Table 6a, Table 6aa, or 6b.

ID: 2202

(2.10.2) 3.B.2.b) Atmospheric Temperature Profile and Atmospheric Humidity Profile

ID: 2203

In the case of the temperature profile, this consists of a set of estimates of the average atmospheric temperature, in each of the sampling layers in NOAA's NWS specified vertical sampling scheme, in a three-dimensional volume (cell) centered on a specified point on a vertical line extending above a fixed longitude and latitude. The observational accuracy requirements given in Table 1 represent errors in a given layer. In the case of the atmospheric humidity profile, this consists of a set of estimates of the precipitable water, in each of the sampling layers in NOAA's NWS specified vertical sampling scheme, in a three-dimensional volume (cell) centered on a specified point on a vertical line extending above a fixed longitude and latitude. The observational accuracy requirements given in Table 1 represent errors in a given layer.

ID: 2204

(2.10.2) 3.B.2.c) Radiances

ID: 2205

Several national centers plan to use radiance information, however the radiance needs are currently consistent with the sounding requirements. The radiance values from the HES will be reported to the NOAA's NWS.

ID: 2206

(2.10.2) 3.B.2.d) Spatial Sampling

ID: 2207

This corresponds to the 2-dimensional horizontal ground sampling distance in km at nadir.

ID: 2208

For the DS task, the THRESHOLD spatial sampling of the IR bands shall be 10 km in both directions, measured at the satellite sub-point (SSP). The visible band shall have 1-km ground sample distance in both directions, measured at the satellite sub-point (SSP). The centroid-to-centroid distance between adjacent samples shall be no larger than the same dimension at SSP, eliminating gaps between samples. The GOAL spatial sampling should be 2 km in both directions for the IR bands and 0.5 km in both directions for the visible band(s), at the SSP. If finer spatial sampling is afforded, the instrument must be commandable to transmit samples with the threshold spatial sampling (within a small variation).

ID: 2209

For the SW/M task, the THRESHOLD spatial sampling of the IR bands shall be 4 km in both directions, measured at the satellite sub-point (SSP). The visible band shall have 1-km ground sample distance in both directions, measured at the satellite sub-point (SSP). The centroid-to-centroid distance between adjacent samples shall be no larger than the same dimension at SSP, eliminating gaps between samples. The GOAL spatial sampling should be 2 km in both directions for the IR bands and 0.5 km in both directions for the visible band(s), at the SSP.

ID: 2210

For the OO task, the THRESHOLD spatial sampling of the reflective solar bands shall be 4.0 km (TBR) in both directions, measured at the satellite sub-point (SSP). The centroid-to-centroid distance between adjacent samples shall be no larger than the same dimension at SSP, eliminating gaps between samples. The GOAL spatial sampling should be 1.0 km (TBR) in both directions for the reflective solar bands at the SSP. There is a longwave IR band that is often used for sea surface temperature; however, that coverage will be included in the ABI as well as the DS task of the HES but at reduced resolution.

ID: 2211

For the CW task, the THRESHOLD spatial sampling of the reflected solar bands shorter than 1 um shall be 0.3 km (TBR) in both directions, measured at the satellite sub-point (SSP). The THRESHOLD spatial sampling of the reflected solar bands longer than 1 um shall be 1.2 km (TBR) in both directions, measured at the satellite sub-point (SSP). The centroid-to-centroid distance between adjacent samples shall be no larger than the same dimensions at SSP, eliminating gaps between samples. The GOAL spatial sampling should be 0.15 km (TBR) in both directions for the reflected solar bands shorter than 1 um at the SSP. The GOAL spatial sampling should be 0.9 km (TBR) in both directions for the reflected solar bands longer than 1 um at the SSP. There is a longwave IR band that is often used for sea surface temperature; however, that coverage will be included in the ABI at reduced resolution. Since it does not appear likely that the resolution will be significantly better in the HES, this is a GOAL band to have it generated by the same instrument as the other CW tasks. The THRESHOLD resolution is 2.0 km for this GOAL band. The GOAL resolution is 1.0 km.

In the CW task, the HES-CW localized mode (under study) has a spatial resolution finer than 0.300 km that approach 0.150 km (TBR).

In the CW task, the "HES-CW localized mode 570" (under study) has a spatial resolution of 0.300 km (TBS).

ID: 2212

For all tasks, NOAA requires instrument-condition data to afford the best possible ground calibration.

Discussion: Algorithms employing the observational data and any necessary instrument-condition data for the ground-processing system will operate at near-real-time, as dictated by the instrument(s).

ID: 2213

Discussion: Because it is a goal for the DS task, the 4-km goal Ground Sampled Distance (GSD) is preferred over the 10 km THRESHOLD GSD. Because it is a goal for the SW/M task, the 2-km goal Ground Sampled Distance (GSD) is preferred over the 4-km THRESHOLD GSD.

ID: 2214

It is understood that the GSD in the DS task and in the SW/M task covering the mid-wave spectral region(s) (and hence the water vapor region) may be an improved spatial resolution compared to that for the longwave spectral region(s) or the shortwave spectral regions if present. The reason for this is that portions of the midwave band are used for moisture that varies spatially more than the temperature varies spatially. (The temperature near the surface also varies spatially but less variation is sensed at higher altitudes as observed along the CO_2 feature.) However, the ratio of the improved midwave sampling shall be chosen so that the ratio of the longwave GSD and shortwave GSD if present to the midwave GSD is an integer.

ID: 2215

Benefits: Increasing the spatial resolution greatly increases the likelihood of obtaining clear-air soundings, and improves the ability of HES to obtain soundings adjacent to cloudy regions. There is a need to perform sounding under all conditions including cloudy conditions. A microwave instrument is anticipated to fulfill this need but there may be retrievals performed above cloud tops using an IR sounder.

ID: 2216

Further Discussion: The spatial resolution of 10 km for the DS task corresponds approximately to that of the GOES I-M sounders, and is the coarsest acceptable spatial resolution of the HES. Because a sounding retrieval process is corrupted by the presence of cloud cover over even a portion of an IFOV (due to the high contrast in brightness temperature between clear and cloudy air), or by optical and focal plane effects, it is necessary to further refine the requirement for spatial resolution by specifying the detector-optics ensquared energy. This quantity specifies ensquared energy performance at the system level, with the phrase detector-optics used to emphasize the difference from the more typical usage of ensquared energy to refer to the optical performance only.

ID: 2217

(2.10.2) 3.B.2.e) Detector-Optics Ensquared Energy (DOEE) and Modulation Transfer Functions (MTFs) for the OO and CW tasks

ID: 2218

The DOEE is a unitless figure of merit, which is the ratio of the energy *detected by* a pixel from its corresponding single ground sample to the energy *detected by* this pixel from the entire large and uniform scene. A pixel is defined as an electro-optical system parameter comprising the radiance measurements in a rectangular area with dimensions on each side equal to the nadir ground sample distance (nominally 10 km or 4 km for the DS task, etc.). Scanning of the line of sight to cover the ground sample distance should be included. For a dispersive system, the DOEE applies only in the direction that is perpendicular to the slit, namely the non-dispersive direction. Also, see section (2.10.2) 3.B.20 on spectral purity for another constraint on spectral crosstalk. Detector-optics ensquared energy provides a measure of the rejection of out-of-field energy, addressing the diffraction spreading effects. As it is used here, the quantity does include focal plane crosstalk issues from adjacent detector samples. It is anticipated that appropriately small optical and electrical crosstalk should be achievable if measures are implemented such as reducing the detector fill-factor to optically isolate the FOVs, and/or by spatially tapering ("apodizing") the pupil illumination to reduce optical crosstalk arising from diffraction effects as well as diffusion effects. Without these measures, it is anticipated that the crosstalk will exceed the low levels of 2.5 percent from all neighbors used in determining the detector-optics ensquared energy values below.

Footnote: Based on Phase-A studies at MIT-Lincoln Laboratory.

ID: 2219

This quantity can be understood in terms of the scene-spread function, which is the convolution of the polychromatic system point-spread function (PSF) at the detector focal plane with the detector pixel geometry and signal spreading from the optics and the detector. Upon projecting (geometrically) this quantity to the earth scene, the relative response of the system as a function of location is obtained. The detector-optics ensquared energy is determined from measurement of the derivative of detector response to a knife-edge scanned across it and across its neighbors. The ratio of the signal from the geometric size of the central pixel to the signal from outside the geometric pixel size is the detector-optics ensquared energy.

ID: 2220

The ensquared energy varies with wavelength and can vary with pixel size. Table 3a. and Table 3b. show the threshold and goal ensquared energies in the DS task for an interferometric spectrometer and a dispersive spectrometer, respectively, at several wavelengths for both the 10 km x 10 km pixels and the 4 km x 4 km pixels. These wavelengths are not more important that other wavelengths but examples of the variation with wavelength. Table 3c and Table 3d show the threshold and goal ensquared energies in the SW/M task for the interferometric spectrometer and the dispersive spectrometer, respectively, at multiple wavelengths for the 10 km x 10 km pixels, the 4 km x 4 km pixels and the 2 km x 2 km pixels. The values for the 4 km pixel there are marked TBR since they are currently not consistent with the NEdN values listed in the Table 6c and 6d.

ID: 2221

Table 3e, Table 3f1, Table 3f2, Table 3f3 and Table 3g contain threshold requirements on MTF that shall be met to address similar specifications in the reflected solar spectral ranges for the OO, CW reflected solar <1 um region, CW reflected solar > 1 um region, and CW LWIR region, respectively. Table 3h contains the MTF requirements that shall be met for the visible channel for either the HES-DS task or the HES-SW/M task.

ID: 2222

Table 3a. The DOEE for an interferometric spectrometer performing the DS task

Detector-Optics Ensquared Energy for the interferometric spectrometer	13 um Threshold / Goal	6 um Threshold / Goal
For 10 x 10 km pixel (THRESHOLD pixel size)	90% / 93%	> or = 90% / > or = 93%
For 4 x 4 km pixel	> or = 64% / > or = 90%	> or = 64% / > or = 90%

ID: 2236

Table 3b. The DOEE for a dispersive spectrometer performing the DS task

Detector-Optics Ensquared Energy for the dispersive spectrometer	13 um Threshold / Goal	6 um Threshold / Goal	4.5 um Threshold / Goal	4 um Threshold / Goal
For 10 km spatial pixel (THRESHOLD pixel size)	90% / 93%	> or =90% / > or = 93%	> or = 90% / > or = 93%	> or = 90% / > or = 93%
For 4 km pixel	> or = 64% / > or =90%	> or = 64% / > or = 90%	> or = 64% / > or =90%	> or = 64% / > or = 90%

	=90%			

ID: 2256

Table 3c. The DOEE for an interferometric spectrometer performing the SW/M task

Detector-Optics Ensquared Energy for the interferometric spectrometer	13 um Threshold / Goal	6 um Threshold / Goal
For 10 x 10 km pixel (matches DS THRESHOLD pixel size)	90% / 93%	> or = 90% / > or =93%
For 4 x 4 km pixel (THRESHOLD pixel size)	> or = or =64% (TBR)/ 90%(TBR)	> or = 64% (TBR)/ > or = 90%(TBR)
For 2 x 2 km pixel (GOAL pixel size)	> or =90% (TBR)/ > or =93%(TBR)	> or =90% (TBR)/ > or =93%(TBR)

ID: 2274

Table 3d. The DOEE for a dispersive spectrometer performing the SW/M task

Detector-Optics Ensquared Energy for the dispersive spectrometer	13 um Threshold / Goal	6 um Threshold / Goal	4.5 um Threshold / Goal	4 um Threshold / Goal
For 10 km spatial pixel (matches DS threshold pixel size)	> or =90% / > or =93%	> or =90% / > or =93%	> or =90% / > or =93%	> or =90% / > or =93%
For 4 km pixel (THRESHOLD pixel size)	> or =64% (TBR)/ > or =90%(TBR)	> or =64% (TBR)/ > or =90%(TBR)	> or =64% (TBR)/ > or = 90%(TBR)	> or = 64% (TBR)/ > or = 90%(TBR)
For 2 km pixel (GOAL pixel size)	> or =90% (TBR)/ > or = 93%(TBR)	> or =90% (TBR)/ > or = 93%(TBR)	> or =90% (TBR)/ > or = 93%(TBR)	> or =90% (TBR)/ > or =93%(TBR)

ID: 2300

Table 3e. MTF for the instrument performing the OO task

Spatial Frequency		System MTF
(km/cyc)	(cyc/rad)	
32.0	1125	0.90 (TBR)
16.0	2250	0.73 (TBR)
10.66	3375	0.53 (TBR)
8.0	4500	0.32 (TBR)

ID: 2324

Table 3f1. The THRESHOLD MTF in the reflected solar < 1 um for the HES-CW.

Spatial Frequency		System MTF
(km/cyc)	(cyc/rad)	
2.4	15000	0.90 (TBR)
1.2	30000	0.73 (TBR)
0.8	45000	0.53 (TBR)
0.6	60000	0.32 (TBR)

ID: 2348

Table 3f2. The THRESHOLD MTF in the reflected solar > 1 um for the HES-CW

Spatial Frequency		System MTF
(km/cyc)	(cyc/rad)	
9.6	3750	0.90 (TBR)
4.8	7500	0.73 (TBR)
3.2	11250	0.53 (TBR)
2.4	15000	0.32 (TBR)

ID: 2372

Table 3f3. The THRESHOLD MTF in the LWIR for the HES-CW

Spatial Frequency		System MTF
(km/cyc)	(cyc/rad)	
16.0	2250	0.84
8.0	4500	0.62
5.33	6750	0.39
4.0	9000	0.22

ID: 2396

Table 3h. Visible band for HES-DS or HES-SW/M MTF

Spatial Frequency	System MTF

(km/cyc)	(cyc/rad)	
8.0	4500	0.85 (TBR)
4.0	9000	0.73 (TBR)
2.666	13500	0.53 (TBR)
2.0	18000	0.32 (TBR)

ID: 2420

Discussion: The retrieval of soundings through “holes” in cloud cover, and near the edge of cloud-covered regions, is corrupted by crosstalk between samples that causes cloud contamination to affect nominally cloud-free FOVs. During Phase-A concept design and technology studies, it was determined that meeting an 80% detector-optics ensquared energy for the DS task requirement would entail an aperture diameter of at least 25 cm, and that further improvement in detector-optics ensquared energy (>90% would be gained by additional measures such as reducing the detector fill-factor to optically isolate the FOVs, and/or by spatially tapering (“apodizing”) the pupil illumination to reduce optical crosstalk arising from diffraction effects. It is expected that instrument performing the DS task may be less susceptible cloud corruption than the GOES I-M sounder if measures such as these are implemented.

ID: 2421

(2.10.2) 3.B.2.f) Horizontal Cell Size

ID: 2423

Horizontal cell size is a measure of the area (assumed square), which corresponds to either the reporting sample, for a retrieved sounding in the case of the DS or SW/M, or a reporting sample size in the case of the OO and CW tasks.

For all task, the THRESHOLD horizontal cell size is equivalent to the THRESHOLD spatial sampling size (see 3.B.2.d. above), measured at the SSP. For all task, the GOAL horizontal cell size is equivalent to the GOAL spatial sampling size (see 3.B.2.d. above), measured at the SSP.

Discussion: In the GOES-R timeframe, the horizontal cell size corresponds to the IFOV. The cell size may contain multiple sub-threshold IFOVs when averaging of several cells are used to reduce NEdN.

ID: 2424

(2.10.2) 3.B.2.g) Sensing Wavebands

ID: 2425

As noted in Section 2.A. Instrument Description Assumptions, options exist for coverage of the spectrum to provide water vapor and temperature sounding information throughout the atmospheric regions of interest of the sounding tasks. Examples are given here for the spectral regions in which DS and SW/M observations can be obtained and processed to retrieval profiles for the DS and SW/M tasks. Also included here are the spectral regions of interest for the OO and CW observations that will be obtained and subsequently processed to obtain OO, or CW parameters. Meeting these spectral ranges and resolutions will be considered sufficient to provide the retrieval performance parameters noted earlier in this document. Other combinations of observation of the two CO_2 features, the ozone band, clear windows in the LWIR, volcanic ash near 8.5 um, and thin cirrus detection, and the water vapor feature in the midwave may also produce sufficient spectral coverage for the DS and SW/M tasks. The details of this are discussed more below. These comments also apply to the NEdN values listed in section (2.10.2) 3.B.2.n. The first paragraph below has general information about the spectroscopy involved. The second paragraph has information about an abstracted listing of spectral coverage. Further information can also be found about the DS and SW/M spectral coverage in the subsequent discussion section below the tables.

ID: 2426

In general, high spectral resolution permits the isolation of spectral information containing desirable sounding properties, such as sharp temperature or water vapor weighting functions in spectral intervals free from contamination by trace gas absorption. In addition it allows for very clear atmospheric windows. High spectral resolution also allows for many spectral observations containing redundant information about surface and atmospheric conditions, which can be utilized together to reduce the effective noise of the set of observations and further improve the accuracy of the soundings. Kaplan et al. (1977) show that it is desirable to be able to resolve spectral features in order to produce sharp temperature and moisture weighting functions in channels between the absorption lines. The main absorption features in the 15 um CO_2 band, which is used for temperature sounding, are roughly 1.5 cm^{-1} apart. Therefore, a spectral resolution of the order of 0.75 cm^{-1} would resolve these spectral features well. The most opaque feature of this band occurs at 667 cm^{-1}, with roughly equivalent atmospheric information occurring in the spectral intervals +/-100 cm^{-1} from this center, providing information about temperature profile from 1 hPA to the surface. In the window regions covering 770 cm^{-1} to 1000 cm^{-1}, and 1070 cm^{-1} to 1200 cm^{-1}, a coarser spectral resolution ($\approx$ 1-2 cm^{-1}) is adequate to isolate the weak absorption lines; however, the first region contains lines that are important in determining cloud emissivity and cloud type so ~1 cm^{-1} or less (TBS) is more appropriate there. The intervening region between these two windows near 9.6 um (1040 cm^{-1}) contains absorption by many closely spaced O_3 lines. Information about the O_3 profile can be obtained even if these lines are not resolved. Because the ozone is used as a tracer, initially retrievals from the ozone feature will employ only a small number of levels. Water vapor profile information from the surface to 100 hPa is contained in the spectral interval 1200 cm^{-1} to 1600 cm^{-1}, and equivalent information is contained from 1600 cm^{-1} to 2000 cm^{-1}. A spectral resolution of the order of 1-2 cm^{-1} is sufficient to resolve these lines. Temperature sounding information is also contained in the spectral interval 2180 cm^{-1} - 2400 cm^{-1}. The spectral interval 2380 cm^{-1} to 2400 cm^{-1} is particularly significant for tropospheric temperature sounding. In this spectral region, a spectral resolution of 0.3 cm^{-1} is needed to resolve these lines, but important sounding information would be contained in channels in this interval even if the spectral resolution were 2.0 cm^{-1} (Kaplan et al., 1977). A window region exists from 2400 cm^{-1} to 2700 cm^{-1}. A spectral resolution of the order of 3 cm^{-1} is sufficient to isolate the weak absorption features here. Shortwave window channel observations, particularly in the most transparent channel at 2616 cm^{-1}, are also useful if they can be achieved with adequate signal to noise.

ID: 2427

The abbreviated spectral coverage requirements listed below have been abstracted from the examples listed below in Tables 4a, 4aa, and 4b. The first eight values together provide profile coverage of temperature information from the CO_2 feature near 15 um, clear window regions, coverage of the ozone feature neat 9.6 um, and detection of volcanic ash and thin cirrus. The next two points demonstrate water vapor coverage. The last three points provide shortwave coverage, which is helpful in determining tropospheric temperature, surface skin temperature, fire effects and cloud cover including fog. When multiple values are listed in the columns below, for consistency the user should select either 1) the first listing in each column for all columns, 2) the second listing for all columns or 3) the third listing for all columns. The complete listings of the example spectral coverage in Tables 4a, 4aa, and 4b and the corresponding NEdNs listed in Tables 6a, 6aa, and 6b may be helpful in any implementation because they are more detailed. The spectral resolution element listed in the table below is effectively the inverse of the maximum path difference. For the interferometric spectrometer, this is 1/(2L), where +L to -L is the maximum path difference. For the dispersive spectrometer, this is 1/(W(sin $theta_i$ + sin $theta_r$)) where W is the grating width, $theta_i$ is the angle of incidence, and $theta_r$ is the angle of reflection. The slight variation between the achieved resolution and the theoretical resolution is not critical here since the retrieval does not depend strongly on this level of variation. However, for reference the theoretical resolving power (out to the first zero, and 0.88 of half-maximum width) is R_0=lambda/(delta lambda) where lambda is the wavelength of interest and delta lambda is the spectral resolution element. The achieved resolving power is the quantity that is measured. The achieved resolving power is not only the convolution of the spectral feature with the dispersive/interferometric element function but also includes the convolution of the slit width. Thus the achieved resolving power (in terms of the half-maximum width) is R= R_0/u where u is the reduced slit width defined as the ratio of the exit slit width to the diffraction slit t width. Typical u is approximately 1.4, although it depends on the details of the system. More background information is included in the discussion for this section following the multiple tables below.

Discussion: Note that alternate definitions of the resolution element for the types of intstrument alter the size of the resolution element from the values listed below. This occurs in the HES PORD.

ID: 2428

Abstracted DS and SW/M task spectral coverage and resolution elements.

Wavenumber (cm^{-1})	Resolution element (cm^{-1})
650	0.625
670	0.625
700	0.625
750	0.625
800	0.625
950	0.625 or 0.75
1150	0.625 or 0.90
1200	0.625 or 0.94
1258 or 1923 or 1258	1.25 or 0.625 or 1.25
1650 or 1644 or 1650	1.25 or 0.625 or 1.25
2150 or 2141 or 2150	2.50 or 0.625 or 2.50
2350 or xx or 2350	2.50 or xx or < 2.50
2513 or xx or 2513	2.50 or xx or < 2.50

ID: 2472

As a goal, coverage of both sides of the water vapor feature (1200 - 1650 cm^{-1} and 1650 - 2150 cm^{-1}) should be provided.

ID: 2473

A dispersive spectrometer is usually specified in terms of wavelength rather than wavenumber. Thus, the waveband sampling for dispersive spectrometer in the DS and SW/M tasks is specified in a separate table, which lists the resolution in wavelength and wavenumber. Examples 1 and 2 in Tables 4a and 4aa are listed in wavenumber while example 3 in Table 4b is listed in wavelength.

ID: 2474

For the dispersive spectrometer(s) performing the DS task and the SW/M task, the wavebands listed below can be covered, but several dispersive elements may cover an IR band. Thus, the narrower spectral range covered by a dispersive spectrometer will be called a spectral region, rather than a spectral band.

ID: 2475

For the OO task, the threshold and goal bands are listed in Table 4c. The threshold bands and applications are listed here. The goal channels provide all channels in the range to accommodate more products. The bands listed here are combination of common ocean bands. ***

ID: 2476

A.1.1.1.1 OO Task Spectral Bands

Wavelength (um)	Application
0.4 -1.0 um continuous or all of the bands listed below (GOAL)	All of below plus additional
0.412 (GOAL)	Dissolved organic carbon
0.443 (THRESHOLD)	Chlorophyll a absorbance, yellow substances
0.477 (GOAL)	Fluorescence Chlorophyll a, Absorption Chlorophyll b, O2:O2 dimmer
0.490 (THRESHOLD)	Water depth (from reflection by sea grass, absorption by pigments), Chlorophyll a (empirical)
0.510 (GOAL)	Accessory Pigments
0.530 (THRESHOLD)	Suspended sediment
0.550 (THRESHOLD)	Chlorophyll a Baseline, backscatter sediments
0.645 (THRESHOLD)	Vegetation (MODIS)
0.667 (THRESHOLD)	Chlorophyll a absorption, Vegetation, Fluorescence, coccolith concentration
0.678 (GOAL)	Fluorescence, Vegetation
0.750 (GOAL)	Atmospheric correction (cloud reflectance), Vegetation
0.763 (GOAL)	O2 A band
0.865 (THRESHOLD)	Vegetation reflection, Atmospheric correction, atmospheric suspended solids, Fluorescence Chlorophyll c (red algae), suspended organic solids
0.905 (GOAL)	Column water

ID: 2526

A.1.1.1.2 CW Task Spectral Bands

For the CW task, the threshold and goal bands are listed in Table 4d. The threshold bands and applications are listed here. The goal channels provide all channels in the range to accommodate more products.

Wavelength (um)	Application
0.4 - 1.0 um centered at 0.667 um (GOAL) or 0.4 - 2.285 um centered at 0.667 um (additional GOAL)	All of the applications below for lambda less than 1.0 um (or 2.285 um) and the ability to form additional bands for new applications
0.412 (THRESHOLD)	Dissolved organic carbon
0.443 (THRESHOLD)	Chlorophyll a absorbance, yellow substances
0.477 (THRESHOLD)	Fluorescence Chlorophyll a, Absorption Chlorophyll b, O2:O2 dimmer
0.490 (THRESHOLD)	Water depth (from reflection by sea grass, absorption by pigments), Chlorophyll a (empirical)
0.510 (THRESHOLD)	Accessory Pigments
0.530 (THRESHOLD)	Suspended sediment
0.550 (THRESHOLD)	Chlorophyll a Baseline, backscatter sediments
0.645 (THRESHOLD	Vegetation (MODIS)
0.667 (THRESHOLD)	Chlorophyll a absorption, Vegetation, Fluorescence, coccolith concentration
0.678 (THRESHOLD)	Fluorescence, Vegetation
0.750 (THRESHOLD)	Atmospheric correction (cloud reflectance), Vegetation
0.763 (THRESHOLD)	O2 A band
0.865 (THRESHOLD)	Vegetation reflection, Atmospheric correction, atmospheric suspended solids, Fluorescence Chlorophyll c (red algae), suspended organic solids
0.905 (THRESHOLD)	Column water
1.38 (GOAL)	Daytime cirrus cloud
1.61 (GOAL)	Daytime cloud water
2.26 (GOAL)	Daytime cloud properties
11.2 (GOAL)	Total water for Sea Surface Temperature (SST)
12.3 (GOAL)	Sea Surface Temperature (SST)

ID: 5867

0.570 (Under study)	Light Use Efficiency (with 0.530 um) for carbon cycle

ID: 2591

Table 4a. Interferometric Sounder Waveband Descriptions Example 1 for DS and/or SW/M tasks (similar to GIFTS bands; see following discussion). A visible band is also required.

Waveband (cm^{-1})	Wavelength (um)	Spectral bin size (cm^{-1})	Number of bins (1840)
650 - 1200	15.38 - 8.33	0.625	880
1650 - 2250	6.06 - 4.44	0.625	960

ID: 2608

Table 4aa. Interferometric Sounder Waveband Descriptions Example 2 for DS and/or SW/M tasks (similar to CrIS bands; see following discussion). A visible band is also required.

Waveband (cm^{-1})	Wavelength (um)	Spectral bin size (cm^{-1})	Number of bins (1532)
650 - 1200	15.38 - 8.33	0.625	880
1210 - 1740	8.26 - 5.74	1.25	424
2150 - 2720	4.65 - 3.68	2.5	228

ID: 2630

Table 4b. Dispersive Sounder Waveband Descriptions Example for DS and/or SW/M tasks (grating type, but not AIRS specifically; see following discussion). A visible band is also required.

Wavelength (um)	Wavenumber (cm^{-1})	Bin size (um)	Bin size (cm^{-1})	Number of bins (~1800)
15.38 -10.54	650 - 950	< or = 0.01um at 12.54 um	0.625 cm^{-1} at the shortwave side of all spectral regions	~600
10.54 -6.25	950 -1600	< or =0.008 um at 8.1 um, < or =0.006 at 6.8 um	1.25 cm^{-1} at the shortwave side of all spectral regions	~600
4.8 - 4.25	2100 - 2350	< or = 0.0023 um at 4.25 um	1.25 cm^{-1} at the shortwave side of all spectral regions	~300
4.25 - 3.85	2351 - 2600	< or = 0.0018 um at 3.85 um	1.25 cm^{-1} at the shortwave side of all spectral regions	~350

ID: 2662

Table 4c. OO Task Band Descriptions (Thresholds and Goals)

Wavelength (um)	Bin size (um)	Number of bins
0.4 -1.0 um (GOAL), centered at 0.667 (thus 0.407 - 0.987)	0.02 (T), 0.01 (G)	35 (T), 58 (G)
0.412	0.02 (T), 0.01 (G)	1
0.443 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.477 (GOAL)	0.02 (T), 0.01 (G)	1
0.490 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.510 (GOAL)	0.02 (T), 0.01 (G)	1
0.530 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.550 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.645 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.667 (THRESHOLD)	0.01	1
0.678 (GOAL)	0.01	1
0.750 (GOAL)	0.02 (T), 0.01 (G)	1
0.763 (GOAL)	0.02 (T), 0.01 (G)	1
0.865 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.905 (GOAL)	0.02 (T), 0.01 (G)	1

ID: 2728

Table 4d. CW Task Band Descriptions (Thresholds and Goals)

Wavelength (um)	Bin size (um)	Number of bins
0.4 - 1.0 um centered at 0.667 um (GOAL) or 0.4 - 2.285 um centered at 0.667 um (additional GOAL)	0.02, 0.8, 1.0	97
0.412 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.443 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.477 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.490 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.510 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.530 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.550 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.645 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.667 (THRESHOLD)	0.01	1
0.678 (THRESHOLD)	0.01	1
0.750 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.763 (THRESHOLD)	0.02 (T), 0.01 (G)	1

0.865 (THRESHOLD)	0.02 (T), 0.01 (G)	1
0.905 (THRESHOLD)	0.035	1
1.38 (GOAL)	0.03	1
1.61 (GOAL)	0.06	1
2.26 (GOAL)	0.05	1
11.2 (GOAL)	0.8	1
12.3 (GOAL)	1.0	1

ID: 5865

0.570 (Under study)	0.01	1

ID: 2814

Discussion: The wavebands in Tables 4a and 4b have been selected for the DS task and the SW/M task based on their utility in producing the desired sounding retrievals, but see comments in this section above. (Of course, for a fuller range of applications, the entire infrared spectra would be ideal.)

ID: 2815

In developing the wave band examples for the interferometer(s) performing the DS task and the SW/M task, the smallest wavenumber (longest wavelength) band was extended from 650-1150 to 650-1200 to include information near 8.5 um. This extension on the shortwave side of the longwave band has kept the interferometric example 1 above from being an exact match to that of CrIS.

ID: 2816

In terms of modeled retrieval performance, the Cooperative Institute for Meteorological Satellite Studies (CIMSS) has shown comparable performance between a Geosynchronous Interferometric Sounder (GIFTS)-like 2 waveband interferometer system (described above as interferometric example 1) and a Cross-track Interferometric Sounder (CrIS)-like 3 waveband interferometer system (with large photovoltaic FPAs) under clear conditions based on noise inputs from MIT-LL and from the GIFTS team (described above as interferometric example 2) (GIFTS will fly on the Earth Observing (EO)-3 as part of NASA's New Millennium Program). AIRS is a flying example of a grating for sounding. AIRS is a multi-detector array grating spectrometer with a roughly constant resolving power $\nu/\Delta\nu \approx 1300$, $(\Delta\nu \approx 0.5\ \mathrm{cm}^{-1} - 1.2\ \mathrm{cm}^{-1})$ and essentially contiguous spectral coverage from 650 cm^{-1} - 1620 cm^{-1} and 2170 cm^{-1} - 2700 cm^{-1} $(\Delta\nu \approx 1.7\ \mathrm{cm}^{-1} - 2.1\ \mathrm{cm}^{-1})$ with spectral sampling of 2 channels per $\Delta\nu$. Each channel has its own detector, with channel noise $(\mathrm{NE}\Delta\mathrm{T\ at\ 250K})$ on the order of 0.1K - 0.2K for the smallest values. The predicted noise for $(\mathrm{NE}\Delta\mathrm{T\ at\ 250K})$ for CrIS is on the order of 0.1K - 0.2K per channel for the smallest values. Thus, the NEdT performance of these instruments is generally the same.

ID: 2817

MIT-LL has done phase A studies for NOAA investigating how to reduce the variation in radiance reflectance that occurs at varying scan angles at certain wavelengths near 8 microns with SiOx mirror coatings used on the current GOES I-M imager and sounder instruments.

ID: 2818

The examples of wavebands for the dispersive spectrometer (s) performing the DS task and the SW/M task has been generalized from those developed in a point design performed for NOAA/NESDIS by MIT Lincoln Laboratory. Ultimately the spectral coverage for the DS and the SW/M tasks is derived from the detailed study of the interferometer retrieval performance for GOES and has been partially optimized for a grating through a detailed discussion with Allen Huang at UW. AIRS is a flying example of a grating for sounding. As part of latest point design study, the specific results were used to further validate the wavebands through retrievals.

ID: 2819

Coverage of these spectral regions near the listed resolution is currently considered sufficient for the DS and SW/M tasks. A more extensive optimization study of the necessary and sufficient wavelength coverage for each wavelength for the DS and the SW/M tasks has been considered by the government team but has not yet begun.

ID: 2820

It is anticipated that the spectral regions for the dispersive system for the DS and the SW/M tasks will have further subdivisions to optimize the instrument. For this reason, the wavelength resolution requirements are not detailed more fully than they are in the table. For the dispersive system for the DS and SW/M tasks, the required spectral coverage does differ from that of the interferometer and the required resolution is actually degraded compared to the two-band interferometer.

ID: 2821

The band listings for each of the OO and CW tasks reflect understanding of current algorithms used to obtain the products listed in the GPRD-1fd.

ID: 2822

(2.10.2) 3.B.2.h) Detailed Discussion of Wavebands for the DS task and the SW/M task

ID: 2823

1) Interferometric Spectrometer: There is no unique set of wavenumbers for an interferometer. The radiance spectrum obtained from the cosine transform of the sampled interferogram is continuous and well defined at all wavenumbers in the band.

ID: 2824

2) Dispersive Spectrometer: There is no unique set of wavelengths for a dispersive spectrometer in general; however, the wavelengths required for the retrievals must be covered by the spectral regions employed in the observations.

ID: 2825

Number of wavenumber channels for the DS task and the SW/M task:

ID: 2826

Interferometric Spectrometer: A fast Fourier transform (FFT) of a sampled interferogram provides a set of spectral radiances uniformly spaced by the wavenumber step size across the band.

ID: 2827

Dispersive Spectrometer: The dispersive spectrometer provides a set of uniformly spaced samples, in wavelength, of spectral radiance across the spectral region of interest.

ID: 2828

Aliasing for the DS task and the SW/M task:

ID: 2829

Interferometric Spectrometer: The interferometric signal shall be appropriately sampled to minimize aliasing and moving mirror velocity fluctuation errors.

ID: 2830

Dispersive Spectrometer: The spectrometer will not experience the same noise terms as the interferometric spectrometer. The signal level of any interference from other orders (ghosts) should be small compared to the NEdN.

ID: 2831

Wavenumber step size for the DS task and the SW/M task:

ID: 2832

Interferometric Spectrometer: The wavenumber bin size ($d\nu$) between spectral data points is defined as the reciprocal of the optical path difference (OPD) between the first and last samples of the sampled interferogram. The wavenumber step size will vary with off-axis field angle and each detector FOV must be appropriately compensated.

ID: 2833

Dispersive Spectrometer: The wavelength bin size is defined by the resolution in Table 4b.

ID: 2834

Unapodized spectral resolution for the DS task and the SW/M task:

ID: 2835

1) Interferometric Spectrometer: The unapodized spectral resolution is defined as the reciprocal of twice the maximum optical path difference from zero path difference (ZPD), i.e. if the maximum OPD change is L, the wavenumber step size is $1/2L$.

ID: 2836

2) Dispersive Spectrometer: The wavelength step size is defined by the resolution in Table 4b.

ID: 2837

Retrieval spectral channel wavenumbers for the DS task and the SW/M task:

ID: 2838

Interferometric Spectrometer: The on-axis set of nominal retrieval spectral channel wavenumbers shall be provided. (see 3.B.20 and comments in section 3.B.2.g on sensing wavebands.)

ID: 2839

Dispersive Spectrometer: The nominal retrieval spectral channel wavelengths shall be provided. (see 3.B.20)

ID: 2840

(2.10.2) 3.B.2.i) Dynamic Range

ID: 2841

The dynamic range for each band containing wavelengths longer than 3 um associated with the DS task and/or the SW/M task shall be sufficient to span the range from the brightness temperature corresponding to the space background to the temperature of the blackbody calibration target, or the highest scene temperature (whichever is larger). This is also intended to prevent saturation (high or low counts) over the life of the instrument and under worse case conditions for the bands containing wavelengths longer than 3 um.

ID: 2842

The dynamic range for each band associated with the OO task shall be sufficient to span the incoming signal range from 0% to 1.1 times the scene signal radiance (TBS), where the radiance levels are located in the radiance appendix. The scene radiance does not include cloud radiances however, the cloud radiances must be measured in each band. A pixel that is located five (TBR) or more pixels away from a saturated cloud edge shall meet the performance specifications and a pixel located more than 3 (TBR) pixels away and less than five (TBR) away should have a signal to noise ratio of no less than one half of the signal to noise. Sun glint is may saturate the pixel; however, a pixel that is located five (Threshold) more pixels away or three (Goal) or more pixels away from a cloud edge shall meet the performance specifications.

To meet these requirements, a full characterization is required for the effects of stray light due to unwanted background signals from high signal levels in the instrument. The spatial variations of the stray light depend on the spatial variations of the cloud cover conditions, which can vary by waveband and thus must be characterized.

ID: 2843

The dynamic range for each band associated with the CW task shall be sufficient to span the incoming signal range from 0% to 1.1 times the scene signal radiance (TBS), where the radiance levels are located in the radiance appendix. The scene radiance does not include cloud radiances however, the cloud radiances must be measured in each band. A pixel that is located five (TBR) or more pixels away from a saturated cloud edge shall meet the performance specifications and a pixel located more than 3 (TBR) pixels away and less than five (TBR) away should have a signal to noise ratio of no less than one half of the signal to noise. Sun glint is may saturate the pixel; however, a pixel that is located five (Threshold) more pixels away or three (goal) or more pixels away from a cloud edge shall meet the performance specifications.

To meet these requirements, a full characterization is required for the effects of stray light due to unwanted background signals from high signal levels in the instrument. The spatial variations of the stray light depend on the spatial variations of the cloud cover conditions, which can vary by waveband and thus must be characterized.

ID: 2844

(2.10.2) 3.B.2.j) System Linearity

ID: 2845

The corrected system response nonlinearity across the instruments' dynamic range for each task shall be measured and demonstrated to be stable enough to meet radiometric performance, and shall be provided to the government.

ID: 2846

(2.10.2) 3.B.2.k) Removed

ID: 2847

(2.10.2) 3.B.2.l) Noise-Equivalent Temperature Difference (NEDT) and Noise-Equivalent Radiance Difference (NEdN) for the DS task and the SW/M task

ID: 2848

The noise performance requirements are defined at the aperture of the system by the noise-equivalent radiance difference (NEdN) arriving from the top of the atmosphere (TOA). The NEdT at a given wavenumber or wavelength is defined by dividing the NEdN at that wavenumber or wavelength by the derivative with respect to temperature of the Planck blackbody radiance function, evaluated at 250 K at the same wavenumber or wavelength.

ID: 2849

(2.10.2) 3.B.2.m) Earth Scene Variation

ID: 2850

The noise performance of the instrument will depend on the earth scene. The earth scenes plotted in Figures 2 through 3 are representative of the extremes in earth radiance.

ID: 2851

Interferometric Spectrometer for the DS task and/or the SW/M task: The interferometer noise will depend on the broadband integrated flux. The blackbody temperatures for equivalent in-band scenes' radiance are given in Table 5a. The radiance levels from blackbodies of these temperatures are plotted in Figures 2a and 2b along with the earth scene radiances that they simulate. From Figures 2a and 2b, blackbody temperatures listed in Table 5.a. are sufficient to produce integrated flux levels representative of the highest and lowest integrated flux expected in each band (see section 3.B.2.g for discussion of wavebands) for the interferometric instrument performing the DS task and/or the SW/M task for the HES instrument on-orbit.

ID: 2852

Dispersive Spectrometer for the DS task and/or the SW/M task: The dispersive spectrometer noise performance will depend on the flux in the resolution element. The simulated, cloud-free earth scene radiances over the entire 3.84 - 15.4 um region for hot, nominal, and cool scenes are shown in Table 5b (in the radiance appendix document) for a dispersive spectrometer HES on orbit. (See section 3.B.2.g. for discussion of wavebands) Because the spectral regions may be subdivided for the dispersive spectrometer, it would be misleading to provide the maximum blackbody temperature in each spectral region. However, Figure 3 shows the blackbody temperature of the maximum feature along with the reference radiances for on orbit.

ID: 2853

Table 5a. Blackbody temperatures for equivalent in-band scene radiances for interferometer performing the DS task and/or the SW/M task

	Hot (K)	Nominal (K)	Cool (K)
Band 1: 650 - 1200 cm^{-1}	290	267	234
Band 2: 1650 - 2250 cm-1	271	251	235

ID: 2871

Table 5b. Earth-scene radiances for dispersive spectrometer (See separate Appendix Document.)

ID: 6333

<Picture>

ID: 2873

Figure 2a. Three earth radiance profiles for 650 to 1200 cm^{-1}. The blackbody temperatures that produce the equivalent in-band radiance for the interferometric spectrometer performing the DS task and/or the SW/M task are shown for hot, nominal, and cool scenes.

ID: 6334

<Picture>

ID: 2875

Figure 2b. Three earth radiance profiles for the 1650 to 2250 $cm^{-1.}$ The blackbody temperatures that produce the equivalent in-band radiance for the interferometric spectrometer performing the DS task and/or the SW/M task are shown for hot, nominal, and cool scenes.

ID: 6337

<Picture>

ID: 2876

Figure 3. Three earth radiance profiles for the dispersive spectrometer performing the DS task and/or the SW/M task are shown for hot, nominal, and cool earth scenes. The blackbody temperatures for the

maximum earth scene radiances are shown at various wavenumbers/wavelengths in the figure. The radiances are provided in Table 5b (in the appendix document).

ID: 2877

(2.10.2) 3.B.2.n) Noise Radiance Performance and Signal to Noise

ID: 2878

Under normal operating conditions, the portion of the HES performing the DS task shall be designed to be consistent with the abstracted listing below in the following unnumbered table. See Section (2.10.2) 3.B.2.g for comments on the spectral coverage. In this way the instrument performing this task will provide data consistent with the observational accuracy requirements in Table 1. The abstracted listing is an abbreviated listing that is consistent with the noise performance listed in Table 6a and/or Table 6aa for the interferometric spectrometer and Table 6b for the dispersive spectrometer.

ID: 2879

Table 6a, Table 6aa, and Table 6b reflect both example design studies and retrieval performance studies performed in Phase-A. The example designs cover varied spectral regions. They indicate the maximum allowed noise equivalent radiance error (NEdN) values considered sufficient to meet NOAA's NWS observational requirements under normal operating conditions in clear air in the DS task. These values reflect the need to have similar noise characterizes from the polar-orbiting systems (i.e., CrIS) and the geostationary sounders to obtain the needed retrieval performance in Table 1, including some risk reduction assessments to afford improved spacecraft accommodation.

Again, this represents an example design whose noise performance values produce retrievals meeting NOAA's NWS needs. Meeting these NEdN values, and in particular meeting the requirement of the abstracted NEdN values in the table just below implies sufficient retrieval performance. The system should be flexible in order to permit an increase in the effective dwell time (or rapid repeated data acquisitions over a fixed region) in order to increase the signal-to-noise ratio for selected scans.

ID: 2880

As discussed above, abstracting the NEdN values in Tables 6a, 6aa, and 6b for the DS task yields the abbreviated list below. When multiple values are listed in the columns below, for consistency the user should select one of the following: 1) the first listing in each column for all columns, 2) the second listing for all columns 3) the third listing for all columns. The complete listings of the example NEdN's in Table 6a, 6aa, and 6b will be helpful in any implementation because they are more detailed. The abstracted NEdN's as well as the example listings are plotted in Figure 4. These listings reflect threshold levels. In order to meet all of the points in a spectral band, it may be necessary to achieve NEdN values that are lower than the abstracted NEdN listing. One such point is listed in the abstracted NEdN table below in parenthesis and is only shown to be consistent with the figure below.

ID: 2881

Goal levels are the first and third set of numbers in each of the four columns below and lower noise numbers in any location, particularly the IR. These reflect a lower level of noise performance in the SWIR that should afford better retrieval performance in the presence of clouds. This lower level of noise in the SWIR as a goal is 1/3 of the listed NEdN values.

Wavenumber (cm^{-1})	Resolution element	NEdN (mW/m^2 sr cm^{-1})	NEdT at 250 K (K)

650	0.625	< / = 1.265	< / = 1.036
670	0.625	< / = 0.40	< / = 0.31
700	0.625	< / = 0.212	< / = 0.175
750	0.625	< / = 0.176	< / = 0.147
800	0.625	< / =0.166	< / = 0.146
950	0.625	< / = 0.182	< / = 0.191
1150	0.625	< / = 0.310	< / = 0.483
1200	0.625	< / = 0.529	< / = 0.918 (goal)
1258 or 1923 or 1258	1.25 or 0.625 or 1.25	</= 0.066 or </= 0.050 or </= 0.066	</=0.135 or </=0.853 or < 0.135
1650 or 1644 or 1650	1.25 or 0.625 or (1.25)	</=0.092 or </=0.077 or <0.092 (using 0.05 for the third column meets all point across the band, as shown in Fig. 4)	</=0.605 or </= 0.504 or < 0.605 (using 0.33 for the third column meets all points across the band, as shown in Fig.4)
2150 or 2141 or 2150	2.50 or 0.625 or 2.50	< / = 0.01 or < / = 0.061 or < 0.01	</=0.416 or </= 2.383 or < 0.416
2350 or xx or 2350	2.50 or xx or < 2.50	< / = 0.011 or xx or < 0.01	< / = 0.966 or xx or </= 0.966
2513 or xx or 2513	2.50 or xx or < 2.50	< / = 0.011 or xx or < 0.011	< / = 1.981 or xx or < 1.981

ID: 2953

The same parameters are listed for the portion of the HES performing the SW/M task in Table 6c and Table 6d. Although an abstracted listing is not specifically listed for this task, it would be functionally identical to the abstracted NEdN listing for the DS task above. Table 6e lists the signal to noise required for the OO task. Table 6f lists the signal to noise for the CW task. Typical ocean radiances are less than 100 $W/m^2/um/sr$.

ID: 6338

<Picture>

ID: 2954

Figure 4. Plot of abstracted NEDN listing (symbols) and example NEdN values (lines) for examples 1, 2, and 3 of the HES-DS task.

ID: 2955

Table 6a. Example 1 maximum allowed NEdN for the DS task interferometric example at the Hot Test Target Temperature listed in Table 5a. (For reference, this set of NEdT's evaluated at 250 K has been included. For reference, the bin size has been listed here from the relevant portion of table 4).

Wavenumber (cm^{-1})	Bin size ($cm^{-1)}$	Max. NEdN [$mW/(m^2$ sr cm^{-1})]	(Corresponding NEdT values at 250 K for reference)

650.00000	0.625	1.265	(1.036)
700.00000	0.625	0.212	(0.175)
750.00000	0.625	0.176	(0.147)
800.00000	0.625	0.166	(0.146)
850.00000	0.625	0.166	(0.152)
900.00000	0.625	0.171	(0.168)
950.00000	0.625	0.182	(0.191)
1000.00000	0.625	0.195	(0.223)
1050.00000	0.625	0.210	(0.264)
1100.00000	0.625	0.225	(0.313)
1150.00000	0.625	0.310	(0.483)
1200.00000	0.625	0.529	(0.918)
1650.00000	0.625	0.092	(0.605)
1705.00000	0.625	0.044	(0.346)
1759.00000	0.625	0.045	(0.429)
1814.00000	0.625	0.046	(0.529)
1868.00000	0.625	0.048	(0.670)
1923.00000	0.625	0.050	(0.853)
1977.00000	0.625	0.053	(1.106)
2032.00000	0.625	0.055	(1.413)
2086.00000	0.625	0.058	(1.829)
2141.00000	0.625	0.061	(2.383)
2195.00000	0.625	0.064	(2.310)
2250.00000	0.625	0.067	(4.012)

ID: 3082

Table 6aa. Example 2 maximum allowed NEdN for the DS task interferometric example at the Hot Test Target Temperature listed in Table 5a. For reference, the bin size has been listed from table 4.

Wavenumber (cm^{-1})	Bin size (cm^{-1})	NEdN [$mW/(m^2\ sr\ cm^{-1})$]	Corresponding NEdT values at 250 K for reference (K)
650	0.625	1.155	0.948
670	0.625	0.405	0.332
700	0.625	0.208	0.171

750	0.625	0.173	0.145
800	0.625	0.163	0.142
850	0.625	0.163	0.149
900	0.625	0.169	0.165
950	0.625	0.179	0.187
1000	0.625	0.192	0.217
1050	0.625	0.207	0.257
1100	0.625	0.221	0.305
1150	0.625	0.296	0.361
1200	0.625	0.52	0.913
1210	1.25	0.12	0.215
1258	1.25	0.066	0.135
1306	1.25	0.062	0.143
1355	1.25	0.064	0.168
1403	1.25	0.066	0.196
1451	1.25	0.068	0.234
1499	1.25	0.07	0.285
1547	1.25	0.072	0.345
1595	1.25	0.075	0.425
1644	1.25	0.077	0.519
1692	1.25	0.08	0.601
1740	1.25	0.083	0.736
2150	2.25	0.01	0.416
2202	2.25	0.01	0.507
2254	2.25	0.01	0.594
2306	2.25	0.01	0.750
2358	2.25	0.011	0.919
2410	2.25	0.011	1.124
2461	2.25	0.011	1.457
2513	2.25	0.011	1.981
2565	2.25	0.012	2.607
2617	2.25	0.012	3.324
2669	2.25	0.012	4.241
2721	2.25	0.012	5.407

ID: 3274

Table 6b. Maximum allowed NEdN for the DS task dispersive example at listed Test Target Temperatures. For reference, the bin size has been listed from Table 4.

Wavelength (um)	Wave-number (cm^{-1})	Bin size (um)	Bin size (cm^{-1})	Max. NEdN [mW/(m^2 sr cm^{-1})]	Corresponding NEdT values at 250 K for reference (K)
15.38-10.54	650 - 950	< or = 0.01um at 12.54 um	0.625 cm^{-1} at the shortwave side of all spectral regions	< or = 0.166 at 12.54 um (800 cm^{-1}) assuming a 289 K BB	< or = 0.144 at 12.54 um
10.54--6.25	950-1600	< or = 0.008 um at 8.1 um, < or = 0.006 at 6.8 um	1.25 (TBS) cm^{-1} at the shortwave side of all spectral regions	< or = 0.092 at 6.06 um (1650 cm^{-1}) assuming a 289 K BB	< or = 0.602 at 6.06 um
4.8--4.25	2100-2350	< or = 0.0023 um at 4.25 um	1.25 cm^{-1} at the shortwave side of all spectral regions	< or = 0.01 at 4.55 um (2195 cm^{-1}) assuming a 287 K BB	< or = 0.58 at 4.55 um
4.25-3.85	2351-2600	< or = 0.0018 um at 3.85 um	1.25 cm^{-1} at the shortwave side of all spectral regions	< or = 0.011 at 4.0 um (2500 cm^{-1}) assuming a 287 K BB	< or = 1.79 at 4.0 um

ID: 3311

Table 6c. Maximum allowed NEdN for the SW/M task interferometric example at the Hot Test Target Temperature listed in Table 5a. For reference, the bin size has been listed from Table 4.

Wavenumber (cm^{-1})	Bin size (cm^{-1})	Max. NEdN [mW/(m^2 sr cm^{-1})]	Corresponding NEdT values at 250 K for reference (K)
650	0.625	1.155	0.948
670	0.625	0.405	0.332
700	0.625	0.208	0.171
750	0.625	0.173	0.145
800	0.625	0.163	0.142
850	0.625	0.163	0.149
900	0.625	0.169	0.165
950	0.625	0.179	0.187
1000	0.6	0.192	0.217

1050	0.6	0.207	0.257
1100	0.6	0.221	0.305
1150	0.6	0.296	0.361
1200	0.6	0.52	0.913
1210	1.25	0.12	0.215
1258	1.25	0.066	0.135
1306	1.25	0.062	0.143
1355	1.25	0.064	0.168
1403	1.25	0.066	0.196
1451	1.25	0.068	0.234
1499	1.25	0.07	0.285
1547	1.25	0.072	0.345
1595	1.25	0.075	0.425
1644	1.25	0.077	0.519
1692	1.25	0.08	0.601
1740	1.25	0.083	0.736
2150	2.54	0.01	0.416
2202	2.54	0.01	0.507
2254	2.54	0.01	0.594
2306	2.54	0.01	0.750
2358	2.54	0.011	0.919
2410	2.54	0.011	1.124
2461	2.54	0.011	1.457
2513	2.54	0.011	1.981
2565	2.54	0.012	2.607
2617	2.54	0.012	3.324
2669	2.54	0.012	4.241
2721	2.54	0.012	5.407

ID: 3503

Table 6d. Maximum allowed NEdN for the SW/M task dispersive example at listed Test Target Temperatures. For reference, the bin size has been listed from Table 4.

Wavelength (um)	Wave-number (cm^{-1})	Bin size (um)	Bin size (cm^{-1})	Max. NEdN [mW/(m^2 sr cm^{-1})]	NEdT (K)

	(cm^{-1})				
15.38-10.54	650 - 950	< / = 0.01um at 12.54 um	0.625 cm^{-1} at the shortwave side of all spectral regions	< / = 0.166 at 12.54 um (800 cm^{-1}) assuming a 289 K BB	</= 0.144 at 12.54 um
10.54--6.25	950-1600	< / = 0.008 um at 8.1 um, < / = 0.006 at 6.8 um	1.25 (TBS) cm^{-1} at the shortwave side of all spectral regions	< / =0.092 at 6.06 um (1650 cm^{-1}) assuming a 289 K BB	< / = 0.602 at 6.06 um
4.8--4.25	2100-2350	< / = 0.0023 um at 4.25 um	1.25 cm^{-1} at the shortwave side of all spectral regions	< / =0.01 at 4.55 um (2195 cm^{-1}) assuming a 287 K BB	< / = 0.58 at 4.55 um
4.17-3.85	2400-2600	< / = 0.0018 um at 3.85 um	1.25 cm^{-1} at the shortwave side of all spectral regions	< / =0.011 at 4.0 um (2500 cm^{-1}) assuming a 287 K BB	< / = 1.79 at 4.0 um

ID: 3540

Table 6e. Signal to noise for OO task bands. For reference, the bin size has been listed from Table 4.

Wavelength (um)	Bin size (um)	Threshold S/N	Goal S/N
0.4 -1.1 um centered at 0.667 um, or all of the bands listed below (GOAL)	0.02 (T), 0.01 (G)	> or =300:1 (TBR)	> or = 900:1 (TBR) less than 0.7 um
0.412	0.02 (T), 0.01 (G)	> or =300:1 (TBR)	> or =900:1 (TBR)
0.443 (THRESHOLD)	0.02 (T), 0.01 (G)	> or =300:1 (TBR)	> or =900:1 (TBR)
0.477	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	> or = 900:1 (TBR)
0.490 (THRESHOLD)	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	> or = 900:1 (TBR)
0.510	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	> or = 900:1 (TBR)
0.530 (THRESHOLD)	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	> or = 900:1 (TBR)
0.550 (THRESHOLD)	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	> or = 900:1 (TBR)
0.645 (THRESHOLD)	0.02	> or = 300:1 (TBR)	> or = 900:1 (TBR)
0.667 (THRESHOLD)	0.01	> or = 300:1 (TBR)	> or = 900:1 (TBR)
0.678	0.01	> or = 300:1 (TBR)	> or = 900:1 (TBR)
0.750	0.02 (TBR) (T), 0.01 (G)	> or = 300:1 (TBR)	> or = 900:1 (TBR)
0.763	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	> or = 900:1 (TBR)
0.865 (THRESHOLD)	0.02 (T), 0,01 (G)	> or = 300:1 (TBR)	> or = 900:1 (TBR)
0.905	0.035	> or = 300:1 (TBR)	> or = 900:1 (TBR)

ID: 3622

Table 6f. Signal to noise for CW task bands. For reference, the bin size has been listed from Table 4.

Wavelength (um)	Bin size (um)	Threshold S/N (imposed on "minimum" signal from appendix)	GOAL S/N
0.40 -1.1 um , centered at 0.667 um and 11.2, 12.3 um or all of the bands listed below (GOAL)	0.02, 0.8, 1.0	> or = 300:1 (TBR)	900 (TBR)
0.412 (THRESHOLD)	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	900 (TBR)
0.443 (THRESHOLD)	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	900 (TBR)
0.477 (THRESHOLD)	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	900 (TBR)
0.490 (THRESHOLD)	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	900 (TBR)
0.510 (THRESHOLD)	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	900 (TBR)
0.530 (THRESHOLD)	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	900 (TBR)
0.550 (THRESHOLD)	0.02 (T), 0.01 (G)	> or =300:1 (TBR)	900 (TBR)
0.645 (THRESHOLD)	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	900 (TBR)
0.667 (THRESHOLD)	0.01	> or = 300:1 (TBR)	900 (TBR)
0.678 (THRESHOLD)	0.01	> or =300:1 (TBR)	900 (TBR)
0.750 (THRESHOLD)	0.02 (TBR) (T), 0.01 (G)	> or = 300:1 (TBR)	900 (TBR)
0.763 (THRESHOLD)	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	900 (TBR)
0.865 (THRESHOLD)	0.02 (T), 0.01 (G)	> or = 300:1 (TBR)	900 (TBR)
0.905 (THRESHOLD)	0.035	> or = 300:1 (TBR)	900 (TBR)
1.38 (GOAL)	0.03	> or = 300:1 (TBR)	900 (TBR)
1.61 (GOAL)	0.06	> or = 300:1 (TBR)	900 (TBR)
2.26 (GOAL)	0.05	> or = 300:1 (TBR)	900 (TBR)
11.2 (GOAL)	0.8	0.1 K NEdT (TBR) at 300 K	0.05 K NEdT (TBR) at 300 K
12.3 (GOAL)	1.0	0.1 K NEdT (TBR) at 300 K	0.05 K NEdT (TBR) at 300 K

ID: 5870

0.570 (under study, goal)	0.01	> or = 300	> or = 900

ID: 3729

(2.10.2) 3.B.2.o Pixel Performance

ID: 3730

ID: 3731

(2.10.2) 3.B.2.o.1. Spectral Operability for Short Band Breaks for DS and SW/M tasks

ID: 3732

Groupings of contiguous inoperable pixels (as defined in section (2.10.2) 3.B.2.o.3) due to a short band break shall be no longer than 35 (TBS) resolution elements. The location choices of any spectral outages for short band breaks is guided by the critical spectral regions of interest identified in section (2.10.2) 3.B.2.g and retrieval analysis showing importance of spectral various spectral sub-regions. Spectral band breaks described in the spectral band break table below shall bet met.

Band	Sub-Region	Spectral Range (cm^{-1})	Contiguous Missing Threshold Channels per breaks	Breaks (limit)
LWIR	1	650-665	< or =5	< or = 2 (T), 1 (G)
	2	665-672	NONE	-
	3	672-722	NONE	-
	4	722-930	< or =35	< or = 3 (T), 1 (G)
	5	930-960	< or =35	< or = 2 (T), 1 (G)
	6	960-1080	< or =5	< or = 2 (T), 1 (G)
	7	1080-1200	< or =35	< or = 2 (T), 1 (G)
MWIR (example 1)	NA	1650-2150	< or =35	< or = 5 (T), 1 (G)
MWIR (example 2)	NA	1210-1740	< or =35	< or = 6 (T), 1 (G)
SWIR	1	2150-2230	< or 20	1
	2	2230-2380	< or =5	< or = 2 (T), 1 (G)
	3	2380-2390	NONE	-
	4	2390-2570	< or =35	< or = 2 (T), 1 (G)
	5	2570-2720	< or =5	< or = 2 (T), 1 (G)

ID: 6217

Discussion: This section presents the limits on planned spectral band breaks due to the need to separate a band over multiple focal plane arrays. Unlike inoperable spectral channels (next section), which are due to random unforeseen or uncontrollable circumstances in the sensor due to, e.g., detector or electronics outages, missing channels from band breaks will always be present in all pixels. The requirements below present planned band break specifications in terms of the number of missing channels allowed in a break and the number of breaks allowed anywhere within the spectral sub-region.

ID: 3733

(2.10.2) 3.B.2.o.2. Spectral Operability for Short Band Breaks for OO and CW tasks

ID: 3734

The CW task shall have no band breaks (THRESHOLD) if produced from the threshold bands and fewer than two (2) band breaks if a hyperspectral (GOAL) implementation is employed.

The OO task shall have no band breaks if produced from the threshold bands and no more than 1 band break if a hyperspectral (GOAL) implementation is employed.

ID: 3735

(2.10.2) 3.B.2.o.3 General Operability

ID: 3736

For the sounding tasks of the HES, a pixel is a spatial sample and all of its associated spectral samples. For an interferometer all spectral samples occur in one detector element. For a dispersive system, spectral sample from the same ground location occur across multiple detector elements.

An inoperable pixel is therefore a pixel that is not operable as defined below for each type of instrument.

ID: 3741

A histogram of NEdN values is anticipated from all FPAs.

ID: 6071

A pixel is considered fully operable if the channels in the pixel meet all of the other channel requirements and following two conditions are satisfied:

1. The number of channels that fail the noise requirements plus the number of missing channels in planned band breaks is less than the percent failing in the spectral inoperability table below for all spectral sub-regions and
2. The number of contiguous missing channels that fail the noise requirements not including planned band breaks is less than the cluster lengths in the table below for all spectral sub-regions.

ID: 6072

A pixel is considered operable if the channels in the pixel meet all of the channel spatial, spectral, and temporal requirements and following two conditions are satisfied (note: a fully operable pixel is also operable):

1. The number of channels that fail two times the noise requirements plus the number of missing channels in planned band breaks is less than the percent failing in the spectral inoperability table below for all spectral sub-regions and
2. The number of contiguous missing channels that fail two times the noise requirements not including planned band breaks is less than the cluster lengths in the table below for all spectral sub-regions.

ID: 6073

An outage is an inoperable pixel that is defined as a non-responsive (or operationally dead) pixel when the calibrated responsivity in every channel in a band is less than 1% of the mean spectral responsivity across the sub-region of the spectral band of the FPA of interest.

ID: 6074

As a THRESHOLD for the sounding tasks, there shall be no more than 5% (TBR) outages.

ID: 3737

ID: 3738

ID: 3742

As a THRESHOLD, the instrument performing the DS and/or the SW/M tasks shall have at least 50% fully operable pixels.

ID: 3743

As a THRESHOLD, the instrument performing the DS and/or the SW/M tasks shall have at least 84% operable pixels.

ID: 3744

ID: 3745

ID: 3746

ID: 3740

The goal operability for all IR bands is 100%.

ID: 6075

The VIS (Band 4) shall have at least 99.9% fully operable pixels.

ID: 6214

The HES-OO Reflected < 1 um shall have at least 99.9% fully operable pixels

ID: 6076

The HES-CW Reflected < 1 um shall have at least 99.9% fully operable pixels

ID: 6077

The HES-CW Reflected > 1 um shall have at least 87% operable pixels.

ID: 6070

The HES-DS shall have no more than 0.05% (TBR) neighboring inoperable pixels in a 62 LZA frame including diagonal neighbors on a rectangular grid.

The HES-SW/M shall have no more than 0.05% (TBR) neighboring inoperable pixels in a mesoscale frame including diagonal neighbors on a rectangular grid.

ID: 3739

ID: 3747

ID: 3748

ID: 3749

ID: 6309

A.1.1.1.2.1 Spectral inoperability requirements table

Band	Sub-Region	Spectral Range (cm^{-1})	Cluster length for threshold channels	Total channel inoperability per sub-region
LWIR	1	650-665	< or = 5	45% (TBR)
	2	665-672	NONE	0% (TBR)

	3	672-722	< or = 5	10% (TBR)
	4	722-930	< or = 5	10% (TBR)
	5	930-960	< or = 5	25% (TBR)
	6	960-1080	< or = 5	10% (TBR)
	7	1080-1200	< or = 5	40% (TBR)
MWIR (example 1)	NA	1650-2150	< or = 5	25% (TBR)
MWIR (example 2)	NA	1210-1740	< or = 5	20% (TBR)
SWIR	1	2150-2230	< or = 5	20% (TBR)
	2	2230-2380	< or = 5	10% (TBR)
	3	2380-2390	NONE	0% (TBR)
	4	2390-2570	< or = 5	60% (TBR)
	5	2570-2720	< or = 5	15% (TBR)
Total sounding operability				20%
Reflected solar < 1 um	NA	0.4-1.0	0	0%
Reflected solar > 1 um	NA	1.0-2.285	0	0%
LWIR-CW	NA	11.2-12.3	0	0%

ID: 3750

ID: 3751

ID: 3752

ID: 3753

ID: 3754

ID: 3755

ID: 3756

ID: 3757

ID: 3758

ID: 3759

ID: 3760

ID: 3761

ID: 3762

ID: 3763

ID: 3764

ID: 3765

ID: 3766

A non-responsive pixel (or an outage) is one that shows less than 10% of nominal measurable change in output signal as a function of illumination.

ID: 3767

ID: 3768

ID: 3769

ID: 3770

ID: 3771

ID: 3772

For OO task: An OO task pixel is considered fully *operable* if the channels in the pixel meet all other channel requirements and the following two conditions are satisfied:

1. the number of channels that fail the noise requirements plus the number of missing channels in planned band breaks, if any, is less than the percent failing, here 0.1%.

2. the number of contiguous missing channels that fail the noise requirements not including planned band breaks is less than the cluster lengths of 1.

ID: 6215

A pixel is considered non-responsive, or an outage, when it is inoperable *and* the calibrated responsivity in each spectral channel is less than 10% (TBR) of the mean responsivity for the same channel across the entire focal plane array.

ID: 6216

As a THRESHOLD, the OO task **shall** have greater than or equal to the percentage of fully operable pixels, here 99.9%. As a THRESHOLD, the OO task **shall** have fewer outages than 0.1%.

ID: 3773

ID: 3774

ID: 3775

ID: 3776

ID: 3777

ID: 3778

ID: 3779

ID: 3780

ID: 3781

ID: 3782

ID: 3783

ID: 3784

ID: 3785

ID: 3786

(2.10.2) 3.B.3 Navigation

ID: 3787

Navigation refers to the determination of the location of each pixel relative to a fixed reference coordinate system.

ID: 3788

Navigation of the HES and the satellite system by the ground system must be sufficient to meet the science requirements for that instrument. The breakdown between the satellite and each of the instruments will not be specified in this document. All navigation requirements listed herein apply to the end-to-end system, taking all instrument, spacecraft, and ground processing effects into account. These errors for any given pixel(s) can be determined through analysis and simulation, while on-orbit verification will require using landmarks in an image. The HES **shall** be capable of autonomously acquiring stars at the appropriate rate and accuracy, if required to meet INR requirements.

ID: 3789

Unless otherwise specified, all navigation requirements in this document are specified as North/South and East/West angles, in microradians, 3-sigma, and refer to all hours of operation. The Ground Sample Angle is the angle subtended by a single pixel at nadir so that a 10 km IR spatial resolution

THRESHOLD of the DS task by definition subtends a 280 urad GSA. In addition, 3-sigma is interpreted as the arithmetic mean, plus or minus three times the square root of the variance for a population of 100 consecutive observations.

ID: 3790

In this section, "image" or “frame” are synonymous, and refer any programmed scan area data set ranging from a full disk down through the Mesoscale in pixel space, as opposed to detector sample space.

ID: 3791

Navigation error is the angular location knowledge error of pixels or features in an image.

ID: 3792

The navigation error for each HES Task shall not exceed the THRESHOLD values in the Navigation Error Table below for pixels on the Earth’s disk, except during eclipse and as described in Section (2.10.2) 3.B.15.2. The navigation error should not exceed the GOAL values in the Navigation Error Table below except during eclipse and as described in Section (2.10.2) 3.B.15.2.

ID: 3793

Navigation Error Table

HES Task	THRESHOLD	Goal
DS	0.5 IR GSA	0.25 IR GSA
SW/M	0.5 IR GSA	0.25 IR GSA
CW	9 urad (TBR)	7 (TBR) urad
OO	0.5 GSA, for 56 urad max	0.4 GSA, for 44.8 urad max

ID: 3815

(2.10.2) 3.B.4. Data format

ID: 3816

Level 1b data, defined as the final calibrated, navigated HES data output, shall be radiance spectra.

ID: 3817

Discussion: The data format must allow integration of HES data with other NOAA’s NWS data sources. To facilitate data use and integration, level 1b data will be distributed. While a ‘fixed grid’ projection makes sense for the ABI system, due to the non-linear nature and use of the sounder data, the native format is preferred.

ID: 3818

Benefits: In addition to users of the spectra for meteorological applications, this will allow a host of new users in diverse fields of chemistry and land processes.

ID: 3819

(2.10.2) 3.B.5. Co-registration

ID: 3820

Channel to channel registration, or co-registration errors, between IR bands involved in the same task for the DS task and the SW/M task shall not exceed ¼ of the IR GSA (0.25*IR IFOV at the SSP) (THRESHOLD) and 10% of the IR GSA (0.10*IR IFOV at SSP) (GOAL) and shall be acquired nearly simultaneously (see section 3.B.10). If the GSD is not the same for the bands particularly as in the case of the visible band (see 3.B.2.d), then multiple samples from the higher resolution must be combined to match the GSD of the coarser resolution sample. If all channels are observed simultaneously, then the co-registration error collapse to errors of overlapping images. In this case, it in anticipated that the co-registration error would be determined from array image overlap and as such knowledge of the actual co-registration errors at the corners of each array is required so that the shift and the rotation can be determined for all pixels. This shall occur after known optical distortions are characterized and taken into account. If all of the channels are not observed simultaneously, then spacecraft effects will impact the co-registration, increasing the difference in the navigation errors between channels over the scenario of simultaneous observations.

ID: 3821

ID: 3822

If either meeting ¼ of the IR IFOV (THRESHOLD) at the SSP (¼ IR GSA) or meeting 10% or better of the IR IFOV (GOAL) at the SSP (10% of IR GSA) is considered a significant cost driver, the contractors should spell out expected cost versus co-registration error.

ID: 3823

The visible-IR co-registration error for the DS task shall be less than or equal to ¼ of the IR IFOV (THRESHOLD) at the SSP (1/4 IR GSA) (TBR) and less than or equal to 1/10 of the IR IFOV at the SSP (1/10 IR GSA) (TBR) (GOAL).

ID: 3824

The visible-IR co-registration error for the SW/M task shall be less than or equal to ¼ of the IR IFOV (THRESHOLD) at the SSP (1/4 IR GSA) (TBR) and shall be less than or equal to 1/10 of the IR IFOV at the SSP (1/10 IR GSA) (TBR) (GOAL).

ID: 3825

The co-registration error of the reflected solar bands of the OO task shall be less than or equal to 1/4 of the IR IFOV at the SSP (1/4 IR GSA) (TBR) (THRESHOLD) and 1/10 of the IR IFOV at the SSP (1/10 IR GSA) (TBR) (GOAL).

ID: 3826

The co-registration error of the reflected solar bands < 1 um of the CW task shall be less than or equal to 9 microradians (0.3 km at the SSP) (TBR) (THRESHOLD) and less than or equal to 3 microradians (0.25 km at the SSP) (TBR) (GOAL). The co-registration error of the reflected solar bands < 1 um of the CW task to the both the reflected solar > 1 um bands of the CW task and the reflected solar < 1 um bands of the CW task shall be less than or equal to 9 microradians (0.3 km at the SSP) (TBR) (THRESHOLD) and less than or equal to 3 urad (TBR) (0.25 km at the SSP) (GOAL). The co-registration error of the GOAL

LWIR bands of the CW task to the reflected solar bands < 1 um of the CW task and the reflected solar > 1 um shall be less than or equal 14 microradians (0.5 km at the SSP) (TBR) (THRESHOLD) and less than or equal to 7 urad (0.25 km at the SSP) (GOAL).

ID: 3827

Benefits: Since the sounding process for the DS task and/or the SW/M task involves the combination of data from each of the individual spectral regions, it is vital that each of the spectral regions view as closely as possible the same area of the earth nearly simultaneously, with similar scene-spread functions. Although not a sounding the bands employed in either the OO or CW tasks should also view as closely as possible the same area of the earth nearly simultaneously, with similar scene-spread functions within each task because difference products involving multiple bands will be formed. This becomes especially important in regions of strong gradients.

ID: 3828

ID: 3829

(2.10.2) 3.B.6. Removed

ID: 3830

(2.10.2) 3.B.7. Within Frame Registration.

ID: 3831

ID: 3832

All registration requirements listed herein apply to the end-to-end system, taking all instrument, spacecraft, and ground processing effects into account. In this section, "image" or “frame” are synonymous, and refer any programmed scan area data set ranging from a full disk down through the Mesoscale in pixel space, as opposed to detector sample space.

ID: 3833

Unless otherwise specified, all registration requirements in this document are specified as North/South and East/West angles, in microradians, 3-sigma, and refer to all hours of operation. The Ground Sample Angle is the angle subtended by a single pixel at nadir so that a 10 km IR spatial resolution THRESHOLD of the DS task by definition subtends a 280 urad GSA. In addition, 3-sigma is interpreted as the arithmetic mean, plus or minus three times the square root of the variance for a population of 100 consecutive observations.

ID: 3834

(2.10.2) 3.B.7.a. Within Frame, Non-Adjacent Pixel Registration

ID: 3835

Within-frame but non-adjacent registration error is the difference between the measured and nominal distance between any two non-adjacent pixels in an image. Within-frame but non-adjacent registration error shall not exceed the THRESHOLD values in the Within Frame, Non-adjacent Pixel Registration Table below. Within-frame but non-adjacent registration error should not exceed the GOAL values in the Within Frame, Non-adjacent Pixel Registration Table below.

ID: 3836

Within Frame, Non-Adjacent Pixels Table

HES Task	THRESHOLD	GOAL
DS	0.5 IR GSA	0.25 IR GSA
SW/M	0.5 IR GSA	0.25 IR GSA
CW	1.0 (TBR) GSA or 9 urad (TBR)	7 urad (TBR)
OO	0.5 IR GSA	0.25 IR GSA
ABI Back-up mode	0.5 * Vendor IR GSA	42 urad over 120 min (GOES-O equiv.) (TBR)

ID: 3862

(2.10.2) 3.B.7.b. Within Frame, Adjacent Pixel Registration

ID: 3863

Within-frame and adjacent registration error is the difference between the measured and nominal distance between any two adjacent pixels in an image, including line to line and single integration image to single integration image. Within-frame and adjacent registration error shall not exceed the THRESHOLD values in Within Frame, Adjacent Pixel Table below. Within-frame and adjacent registration error should not exceed the GOAL values in Within Frame, Adjacent Pixel Table below.

ID: 3864

Within Frame, Adjacent Pixels Table

HES Task	THRESHOLD	GOAL
DS	0.5 IR GSA	0.25 IR GSA
SW/M	0.5 IR GSA	0.25 IR GSA
CW	1.0 (TBR) GSA or 9 urad max (TBR)	7 urad (TBR)
OO	0.5 IR GSA	0.25 IR GSA
ABI backup mode	0.5 * Vendor IR GSA	20 urad (TBR) over 120 min (GOES-O equiv.)

ID: 3890

Discussion: These requirements are intended to define the limits of acceptable within- image distortions. There will be DS task and/or SW/M task products based on and displayed for each pixel location. There will also be OO and CW products for each pixel.

ID: 3891

Benefits: Since a major use of the DS task and SW/M task data will be in providing information contained in the gradients of the observations, the relative locations are critical.

ID: 3892

(2.10.2) 3.B.8. Frame-to-Frame Registration

ID: 3893

Introductory description in section (2.10.2) 3.B.7 apply here as well.

ID: 3894

Frame to frame registration error is the difference in navigation error for any given pixel in two consecutive images. Since images may be 60 minutes apart, these requirements apply over 60 minute periods. Frame to frame registration errors shall not exceed the THRESHOLD values in the Frame-to-Frame Navigation Table. Frame to frame registration error should not exceed the GOAL values in the Frame-to-Frame Navigation Table.

ID: 3895

Frame-to-Frame Navigation Table

HES Task	THRESHOLD	GOAL
DS	0.5 IR GSA (TBR) over 60 minutes	0.25 IR GSA (TBR) over 60 minutes
SW/M	0.5 IR GSA (TBR) over 60 minutes	0.25 IR GSA (TBR) over 60 minutes
CW	1.0 (TBR) GSA, or 9 urad (TBR), over 60 minutes	7 urad (TBR), over 60 minutes
OO	0.5 IR GSA (TBR) over 60 minutes	0.25 IR GSA (TBR) over 60 minutes
ABI backup mode	0.5 * Vendor IR GSA (TBR) over 60 minutes	42 urad (TBR) over 90 min; 112 urad (TBR) over 24 hours (GOES-O equiv.)

ID: 3921

(2.10.2) 3.B.9. Removed

ID: 3922

(2.10.2) 3.B.10. Data simultaneity

ID: 3923

(2.10.2) 3.B.10.a Band to band Simultaneity

ID: 3924

Data from all bands for the HES-DS task obtained for any specific point on Earth must be coincident within 10 (TBR) seconds (THRESHOLD) and within 5 seconds (GOAL). These values are not to exceed values.

ID: 3925

Data form all bands for the HES-SW/M task obtained for any specific point on Earth must be coincident within 10 (TBR) seconds (THRESHOLD) and within 5 seconds (GOAL).

ID: 3926

Data from all bands for the HES-OO task obtained for any specific point on Earth must be coincident within 30 (TBR) seconds (THRESHOLD) and within 20 seconds (GOAL). These values are not to exceed values.

ID: 3927

Data from all bands for the HES-CW task obtained for any specific point on Earth must be coincident within (TBR) seconds (THRESHOLD) and within 10 seconds (GOAL). These values are not to exceed values.

ID: 3928

Discussion: The simultaneity requirements for the DS, SW/M, OO and CW tasks are needed to ensure accurate generation of any multiband products that depend on data from all spectral bands. In particular, this requirement is imposed to attempt to ensure that cloud cover is consistent during the observations.

ID: 3929

Benefits: Minimizes uncertainty due to cloud contamination and solar heating.

ID: 3930

(2.10.2) 3.B.10.b Pixel to pixel simultaneity

ID: 3931

Data from all adjacent pixels in all adjacent FOVs from the DS task must be sampled within a maximum of 6 minutes (THRESHOLD) of each other when covering the 62-degree local zenith angle and within 3 minutes (THRESHOLD) when covering a CONUS-sized area (defining the swath length), while meeting the coverage rate define in section 3.A.2. The GOAL simultaneity for a CONUS-sized area is 2 minutes, based on the current sounder. These values are not to exceed values.

ID: 3932

Data from all adjacent pixels in all adjacent FOVs from the SW/M task must be sampled within 6 minutes (THRESHOLD) when covering a CONUS-sized area (if collected at part of the 62 degree LZA collection)) and within 3 minutes when covering a 1000 km x 1000 km area, while meeting the coverage rate defined in 3.A.2. The GOAL simultaneity for a CONUS-sized area is 2 minutes, based on the current sounder. These values are not to exceed values.

ID: 3933

Data from all adjacent pixels in all adjacent FOVs from the OO task must be sampled within 18 TBR minute (THRESHOLD) when covering the open ocean in the 62 degree LZA (defining the swath length) while meeting the coverage rate defined in 3.A.2. The GOAL simultaneity is 13 minutes TBR when covering the open ocean in the 62-degree LZA (defining the swath length) while meeting the coverage rate defined in 3.A.2. These values are not to exceed values.

ID: 3934

Data from all adjacent pixels in all adjacent FOVs from the CW task must be sampled within 10 minutes (TBR) minute (THRESHOLD) when covering a 400 km-length (defining the swath length) while meeting the coverage rate defined in 3.A.2. The GOAL simultaneity is TBD when covering the 62-degree LZA (defining the swath length) while meeting the coverage rate defined in 3.A.2. These values are not to exceed values.

ID: 3935

The <u>dominant direction of instrument "scan</u>" must be in the East-West directions for the DS, SW/M and OO tasks. There is no dominant direction of scan for the CW task. To accommodate a possible seasonal Yaw flip (similar to that on the GOES-10 spacecraft), stepping shall be possible in North to South, South to North, West to East, and East to West directions. Ground sample data acquisition <u>should</u> begin with the northernmost coordinate and proceed south. See Section (3.B.13) concerning scan effects on calibration.

ID: 3936

Discussion: The pixel-to-pixel simultaneity requirements for the DS, SW/M, OO and CW tasks are needed to minimize time gaps across swaths. This limits shear between swaths.

ID: 3937

(2.10.2) 3.B.11. Full Operations

ID: 3938

The HES shall be capable of full operations within 1 hour (TBR) following North-South stationkeeping spacecraft maneuvers (THRESHOLD).

ID: 3939

Discussion: Routine operations should not be re-established too quickly to endanger the health or safety of the instrument. The design should minimize degradation to navigation ability from sun exposure on the scan mirror and the rest of the imager.

ID: 3940

Benefits: Excessive delays in resuming routine imaging operations following mandatory outages associated with maneuvers can threaten continuity of weather surveillance and result in degradation of forecasts of severe weather.

ID: 3941

(2.10.2) 3.B.12. Visible band calibration for DS and SW/M tasks

ID: 3942

The visible band of the DS task and/or of the SW/M task shall be calibrated prior to launch to provide albedo to an accuracy of +/- 5% at maximum scene radiance. This visible calibration performed pre-launch should be stable and compared to a NIST reference. The DS and the SW/M visible band(s) shall be quantized in such a way that the signal will not saturate (high counts or low counts) over the life of the instrument and under worst-case conditions. It is anticipated that vicarious calibration will be performed during the life of the instrument performing these tasks. Also, the presence of a reflected solar wavelength calibration on board the ABI and HES should facilitate this calibration process. The required accuracy of that intercalibration will be 5%.

ID: 3943

The calibration required for the reflected solar bands of the OO or CW tasks is discussed in section 3.B.14.

ID: 3944

(2.10.2) 3.B.13. Infrared Calibration for DS and SW/M tasks

ID: 3945

On-orbit and ground calibration must be provided to achieve brightness temperature absolute accuracy of ± 1.0 K (THRESHOLD) for each band and traceable to a NIST radiance standard. (The absolute accuracy requirement means that if the true value for a band is X K, then the calculated values must be between X minus 1 and X plus 1 K.) The GOAL value is 0.5 K A cold reference may be provided by a space look. The relative accuracy (precision) of each band shall be within the NEdN (THRESHOLD) and within 1/3 of the NEdN (GOAL) (1-sigma) for the following categories of relative error: a) swath to swath (where a swath is one traversal of the scan mirror in the east-west directions over the entire scene of interest), b) detector to detector, c) channel to channel, d) calibration to calibration. Optical and structural elements that influence the radiometric response of the instrument to the calibration blackbody shall be temperature monitored such that the corrections to the scene due to these sources will be good to < or = 0.1 K precisions between IR calibrations and telemetered for calibration ground processing.

ID: 3946

The "hot" calibration target will be a blackbody. The calibration method is required to account for both long-term variations such as changing emissivities of the optical elements in front of the blackbody (including scan mirror degradation) and short-term variations such as gain variations of the FPA. It is anticipated that either the 1) the blackbody will be viewed by a rotation of the scan mirror to provide calibration of the entire system or 2) the blackbody will be located inside the optical train and will be accessible by a flip mirror. If option 2 is chosen, a detailed analysis using to the maximum feasible extent current on-orbit instruments data shall be performed to demonstrate that the impact of the approach over the life of the instrument is no greater than the impact from using option 1. At NOAA's discretion, data from end-to-end ground testing may be deemed acceptable in these calculations.

ID: 3947

Radiometric accuracy of the HES system in the DS and SW/M tasks should be independent of scan position (or location of the target in the field of regard). Independent of scan position implies change of less than 0.6 (TBR) % relative to the scene dynamic range with angle. All calibration tolerances are 3-sigma.

ID: 3948

Benefits: All soundings and products rely on accurate calibration.

ID: 3949

(2.10.2) 3.B.14. Reflective solar calibration and polarization control for the OO task and CW task

ID: 3950

Because the IR bands of these tasks do not lie in the thermal IR range (except two bands in the CW task), the IR bands fall into the reflective solar range. The reflective solar of the OO or CW tasks shall be calibrated prior to launch to provide albedo to an accuracy of 3 (TBR) % at maximum scene radiance, listed as "maximum" in the appendix. This reflective solar calibration performed pre-launch should be stable and compared to a NIST reference. These reflective solar bands shall be quantized in such a way that the signal will not saturate (high counts or low counts) over the life of the instrument and under worst-case conditions. An onboard full optical train, full aperture calibrator shall be used to perform calibrations during the life of the instrument performing these tasks (see discussion). The require calibration must provide absolute accuracy of 3% or less at 100% albedo, RMS repeatability of the band difference of +/-0.2% or less, and drift in absolute calibrated radiances of 0.5% over the instrument lifetime. *Relative calibrations accuracy shall be 1% or better. *

For the LWIR bands of the CW task, the IR calibration described in 3.B.13. above applies.

ID: 6050

b) On-board "visible" and reflective solar < 3 um calibration for the OO and CW tasks shall also provide:

ID: 6054

1. Radiance measurements in the reflected solar wavelength range shall be traceable to NIST standards. Assurance of radiance traceability to NIST shall include both 1) a measurement assurance program, (an example of which would be to employ NIST transfer radiometers to the vendor's calibration sources pre-launch or the purchasing of NIST sources (e.g., lamps, blackbodies) and adhering to specified recalibration schedules pre-launch), and 2) use of NIST best practices in radiance determinations, including quality programs detailing measurement procedures and reproducibility and using trained personnel.

ID: 6055

2. The on-board calibration for the solar reflective bands shall be performed at least once a month under routine operations and more frequently (e.g., once a day) during post-launch phase where rapid changes are anticipated.

ID: 6056

3. The calibration shall also employ a technique involving measurements to address long-term stability for the solar reflective wavelengths.

ID: 6057

4. The instrument vendor shall perform at least a pre-launch full-system radiometric calibration in all bands, filling the aperture and the entire optics/detector train as under the operational conditions.

ID: 6058

5. The vendor shall characterize the spectral response as a function of wavelength for each optical element in the optical train.

ID: 6059

6. An independent laboratory approved by the government shall measure the spectral response of witness samples of the critical optical elements, namely the bandpass optical filters.

ID: 6060

Discussion: NOAA wants an onboard, reflected solar < 3 um calibration capability, but it must not introduce significant costs or risks through its approach or technology to the HES's lifetime. A failure of the onboard calibration device shall not cause failure of the entire HES mission. Complementary multiple techniques can be used to implement calibration. A NOAA workshop held on May 19, 1999 explored the availability of onboard ABI visible and near IR technologies and approaches. The results of the workshop are contained in JPL report "In Flight Visible and Near Infrared Calibration of Future GOES Imagers Workshop report," Dave Norris, October 1999, JPL report D-17846. The above onboard calibration requirements identified at the workshop were discussed as limits of what could be achieved. Ultimately, the lowest GPRD product accuracy of 5% is the driver. Thus the radiometric calibration will be tighter, at 3%. What NOAA wants is an onboard capability and some progress towards these limits.

ID: 6061

Alternative Imager, on-board, reflected solar < 3 um calibration designs were discussed, such as

ID: 6062

1. Stable on-board source of illumination;

ID: 6063

2. The sun as a radiometric source via, e.g., reflection from diffuser plates or transmission through perforated plates.

ID: 6064

Standard diodes could be used with the preceding approaches to monitor the output of the on-board source, the reflectivity of the diffuser plate, or the transmittance of the perforated plate.

ID: 6049

Discussion: Instrument intercomparison across platforms in all wavebands will be performed by NOAA, but nothing additional is mandated to the instrument vendor because of this plan.

ID: 3951

All HES channels other than the visible cloud clearing channels of the DS and SW/M tasks with wavelengths <3 microns shall have less than 3 (TBR) % (THRESHOLD) sensitivity to the polarization of incoming light, and, as a goal, they should have less than 1 (GOAL)% (TBR) sensitivity. (See definition of polarization sensitivity in next paragraph.) The difference in sensitivity to polarization between channels shall be less than 2.0% (TBR), with a goal of less than 1.0% (TBR). The uncertainty in the sensitivity to polarization within a channel shall be less than 1% (TBR), with a goal of 0.5% (TBR). The polarization insensitivity requirements shall be met at all Earth-viewing angles throughout the life of the mission, and, as a goal, the insensitivity requirements should be met over the entire field-of-regard.

ID: 3952

Polarization sensitivity is defined as the ratio of the difference between maximum and minimum output to the sum of the maximum and minimum output obtained when the plane of incoming 100% linearly polarized radiation is rotated through 180 degrees.

ID: 3953

Discussion: In NOAA's experience, vicarious calibration provides 5 percent calibration errors while on-board calibration delivers 3% errors. Also, vicarious calibration requires months to years to complete, which is considered too long by NOAA. Because a failure of the on-board calibrator could cause a mission failure if the calibrator blocked the optical path, care must be taken in its design.

ID: 3954

(2.10.2) 3.B.15. Degradation of performance around spacecraft local midnight and around eclipse

ID: 3955

ID: 3956

(2.10.2) 3.B.15.1 Degradation around local midnight

ID: 3957

ID: 3958

Degradation of performance or outages around spacecraft local midnight must be minimized:

ID: 3959

a) Any (thermal IR) radiometric degradation reducing data quality to below specification for the DS task or the SW/M task resulting from sunlight impingement on sounder optics must be limited to when the sun is within 10 degrees of the sounder optical line of sight for each detector element (THRESHOLD).

ID: 3960

b) Any HES outages needed to ensure health and safety of the instrument when sunlight may enter the instrument optics must be limited to when the sun is within 3 degrees of any detector element's line of sight (THRESHOLD).

ID: 3961

c) No IR detector shall saturate.

ID: 3962

(2.10.2) 3.B.15.2 Degradation during eclipse

ID: 3963

a) For the DS task and or the SW/M task, all operable detector elements in the emitted IR bands (650 to 2250 cm^{-1}) shall have NEdN values no more than two (2) times their respective NEdN values under normal operating conditions. See section 3.B.2. Operable detectors are defined in section 3.B.2.o. NEdN values under normal operating conditions are listed in section 3.B.2.m (Table 5a and Table 5b). Requirements placed on the FPA pixels to meet these NEdN values are described in section 3.B.2.o. Recovery time is described in section (2.10.2) 3.B.

ID: 3964

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ID: 3965

c). The calibration performance shall degrade by no more than TBD (THRESHOLD) and 0.5 K (Goal) for a four hour time period, nominally ½ hour prior to an eclipse to 3.5 hours, after the end of an eclipse (also see section 3.B.12). The phasing of the delay may be design dependent.

ID: 3966

d) Image Navigation and Registration shall be permitted to degrade over a 4 hour period near the eclipse. The phase of the period may be design dependent. All eclipse thresholds are written in the form of angles. The Ground Sample Angle is the angle subtended by a single pixel at nadir so that a 10 km IR spatial resolution THRESHOLD of the DS task by definition subtends a 280 urad GSA. The eclipse THRESHOLD level of the navigation requirement for the DS task is 0.75 of the IR detector element IFOV. The eclipse THRESHOLD level of the navigation requirement for the SW task is 0.75 of the IR detector element IFOV. The eclipse THRESHOLD level of the navigation requirement for the CW task is 13.5 urad. The eclipse THRESHOLD level of the navigation requirement for the OO task is 42 urad. The eclipse THRESHOLD level of the navigation requirement for the ABI backup mode is 0.75*(Vendor IR IFOV). For all tasks, the eclipse GOAL navigation is the same as the goal navigation described in section

ID: 3967

Discussion: Section 3.A.1 contains further discussion. Thorough analysis and innovative designs are encouraged to minimize this "keep-out-zone" phenomenon.

ID: 3968

Benefits: See Section 3.A.1 for further benefits. If the "keep-out-zone" phenomenon is minimized, both more and higher quality data can be observed.

ID: 3969

(2.10.2) 3.B.16. Contemporaneous visible imaging capability

ID: 3970

Contemporaneous and collocated visible data are required with the IR data for the DS task and/or the SW/M task. The spectral range is no larger than 0.52 to 0.7 μm. The signal to noise shall be greater than or equal to 300:1 (THRESHOLD) and 600:1 (GOAL) at the 100% albedo level. The resolution shall be 1.0 km (THRESHOLD) with 0.5 km (GOAL).

ID: 3971

Discussion: A serious handicap to producing accurate infrared only sounding retrievals is the difficulty of dealing with cloud contamination. Experience has shown that visible data are of great benefit during daylight hours for identifying cloud-free FOVs, especially the higher resolution visible data (sub-IR pixel size). Perhaps more importantly, however, high-resolution visible data may allow for correcting IR radiances for subpixel cloud contamination, permitting retrievals of clear air sounding and cloud information in more of the meteorologically active areas. High-resolution sounders such as the HES can anticipate frequent cloud contamination near storm systems so that sounding will improve with contemporaneous and collocated high-resolution visible data.

ID: 3972

(2.10.2) 3.B.17. Low-light Visible capability

ID: 3973

In order to address NOAA's NWS need for soundings under all conditions for the DS task and/or the SW/M task, detection of clouds under the lowest low light situations is required. These occur past sunset at the ground point of interest and extend as far as possible into night conditions. The THRESHOLD signal to noise level is 10 (TBR) over a 2 km sample using 5% albedo, although the signal levels mentioned above are even lower.

ID: 3974

ID: 3975

Discussion: Due to the increased dwell times compared to an imager, the sounder visible data may be more sensitive in low-light regions.

ID: 3976

ID: 3977

Benefits: Better depiction of near nighttime fog, clouds, and thunderstorms would be a benefit for soundings. This may also improve knowledge of the location of the center of tropical disturbances.

ID: 3978

(2.10.2) 3.B.18. Downlink Data

ID: 3979

It is assumed that the GOES spacecraft communications sub-system will serve to relay HES data to NOAA ground receive systems in near real time to address latency requirements.

ID: 3980

(2.10.2) 3.B.19. Data compression acceptability

ID: 3981

Commandable data compression that offers a choice between lossless compression (approximately 2:1) and lossy (approximately 4:1 or possibly high) should be afforded.

ID: 3982

(2.10.2) 3.B.20. Spectral Knowledge and Stability

ID: 3983

Knowledge of the spectral line center shall be 1 part in 10^5 (TBR) or better (smaller) over TBS time at the specified wavenumbers (TBS) and wavelengths (TBS) is required.

ID: 3984

Line center stability (GOAL) shall be 3 parts in 10^5 (TBR) over TBS time.

ID: 3985

Discussion: This level of performance is estimated to be required for good retrieval performance. The technical difficulty in maintaining this value must be assessed.

ID: 3986

(2.10.2) 3.B.21 Spectral Purity

ID: 3987

For the sounding tasks, the integrated absolute value of the spectral response from outside the channel of interest **shall** be less than 28% (TBR) of the total spectral response in the channel for a uniformly illuminated aperture.

ID: 3988

BLANK

ID: 3989

2.10.3 Removed

ID: 3990

2.10.4 Space Weather Instrument Properties

ID: 3991

Each GPRD-1fd product requirement for the space weather instruments leads to a separate instrument. Thus the GPRD requirements are the same as the MRD requirements summarized in the tables through this section. All requirements, including those in the text of this section, will be met/addressed by the magnetometer (considered part of the spacecraft), the SIS, and the SEISS described immediately below. For reference only, additional P^3I products are currently listed in Appendix A.

ID: 3992

General

ID: 3993

Space Weather will be measured on GOES-R with the magnetometer and the following 2 suites: the Solar Imaging Suite (SIS) and the Space Environment In-Situ Suite (SEISS) described below. The SIS and the SEISS on GOES-R will monitor the solar EUV (extreme ultraviolet) and X-ray output and the geosynchronous particle environment. The magnetometer will monitor the magnetic environment. The SIS consists of the Solar X-ray imager (SXI), the solar X-ray sensor (XRS), and an extreme ultraviolet sensor (EUVS). The coronagraph will be part of the SIS, but is considered P^3I. The SEISS consists of a set of energetic particle sensors (EPS) that will monitor the particles at geosynchronous orbit. The three-axis vector magnetometer will monitor the geomagnetic field.

ID: 3994

The magnetometer is designed to measure the Earth's magnetic field at geosynchronous orbit. The SIS and SEISS suites of instruments are designed to provide real-time measurement of solar activity and the charged particle environment in geosynchronous orbit. The SXI and the coronagraph provide continuous images of the solar disk in X-ray and white light images of the solar corona, respectively.

ID: 3995

The magnetometer, SIS, and SEISS shall operate and transmit data during eclipses. Each instrument shall operate independently.

ID: 3996

All space and solar condition measurements from GOES-R shall be in real time.

ID: 3997

Products from the GOES-R SIS and SEISS shall provide continuity with GOES existing products, while improving performance.

ID: 3998

Discussion: In particular, the magnetometer, particle sensors, and solar X-Ray sensor of the Space Environment Monitor (SEM) suite in the previous series have a long history of archived data that have proved to be especially useful for many areas of research and space climatology. These space environment measurements made by GOES have become standards for the space weather users.

Beginning with GOES 12, the Solar X-ray Imager (SXI), and beginning with GOES N, the EUV sensors represent new observations that will be used as new standards for space weather forecasters and users.

ID: 3999

In accordance with this continuity, the requirements for the instruments are listed below; where not specifically indicated, the threshold and goal requirements are the same.

ID: 4000

2.10.4.1 Magnetometer

ID: 4001

General

ID: 4002

The Magnetometer shall measure the magnitude and direction of the Earth's ambient magnetic field in three orthogonal directions in an Earth-referenced coordinate system.

ID: 4003

Discussion: A magnetometer provides a map of the space environment that controls charged particle dynamics in the outer region of the magnetosphere. Magnetic field measurements provide information on the general level of geomagnetic activity, monitor current systems in space, and permit detection of magnetopause crossings, storm sudden commencements, and substorms.

ID: 4004

There shall be a magnetometer on orbit for each satellite position, under normal operating conditions.

ID: 4005

The observational parameters and requirements for the magnetometer, listed in the GOES Magnetometer Observational Requirements Table, shall be met.

ID: 4006

All calibration information and algorithms necessary for determination of the ambient field shall be supplied.

ID: 4007

Data must be transmitted to enable the sensor data to be corrected in real time at the SEC; all correction algorithms are required.

ID: 4008

Data Sampling Rate

ID: 4009

Data for determining each component of the ambient magnetic field shall be sampled at a rate listed in the table below. The effective time of each measurement shall be known and each individual component shall be sampled uniformly in time and simultaneously within 25% of the sample period (i.e., within 0.125 seconds for a 2 Hz sampling rate).

ID: 4010

Bandwidth

ID: 4011

The frequency response of the instrument shall discriminate against aliasing of the magnetometer data resulting from the ambient background and spacecraft interference. For a 2 Hz sampling rate, the nominal measurement bandwidth for each component of the vector field shall be defined by a pre-sampling filter such as a fifth order Butterworth filter, with greater than 25 dB attenuation at the Nyquist folding frequency. The nominal 3 dB attenuation frequency shall be one-half the Nyquist folding frequency, with the three components matched to the nominal 3 dB frequency ± 0.75%. The actual frequency response of the measurement shall not deviate from the nominal by more than 0.3 dB in amplitude or 5° in phase anywhere within the nominal 3 dB bandwidth. For a higher sampling rate, the requirement is TBD.

ID: 4012

Noise

ID: 4013

The estimate of the magnitude of the ambient field computed on the ground from the instrument measurement along each axis shall not fluctuate by more than 0.3 nT (THRESHOLD), 3 sigma (TBS), when the spacecraft is in a normal operational mode. Unavoidable step changes, which create out-of-specification transients after ground correction, may occur. They shall not, however, average more than one transient in any one-hour period; and the duration of the out-of-specification transient shall be no greater than five seconds.

ID: 4014

In-flight Calibration

ID: 4015

An on-orbit capability shall be provided to demonstrate that the basic instrument is functional.

ID: 4016

Discussion: This shall be accomplished by adding known fields to the ambient field by ground command.

ID: 4017

A capability shall be provided to determine from the calibration data the sensitivities necessary for calculating the ambient-plus-spacecraft field. This determination shall include calibration field levels covering more than 50% of the full range of the magnetometer.

ID: 4018

The calibration shall also be stable and repeatable during times of quiet ambient field to an accuracy of ±1 nT in each axis at each field level. Magnetometer calibration shall be terminated by ground command.

ID: 4019

ID: 4020

In-flight Magnetometer Effective Offset Determination

ID: 4021

The effective magnetometer instrument offset (instrument plus spacecraft) shall be determined on-orbit via a spacecraft rotation maneuver. The instrument-offset determination shall be made during the spacecraft post-launch test period in the vicinity of local noon,

ID: 4022

Discussion: The design should eliminate spacecraft static and dynamic fields at the instrument location in order to facilitate ground-based data processing. Particular care should be taken to eliminate permeable and permanent magnetic material close to the instrument. A ground test program is necessary to demonstrate that on-orbit specifications will be met: examples included spacecraft stray and DC magnetic interference testing

ID: 4023

2.10.4.1.1 GOES Magnetometer Observational Requirements

Observational parameter	Requirement
Measurement range	+/-400 nT/axis
Measurement precision	0.016nT/axis
Measurement accuracy	1.0 nT/axis
Orthogonality	+/- 0.5 deg
Orientation stability	+/- 0.25 deg (TBR)
Orientation knowledge	Threshold: +/- 1 deg, Goal: +/- 0.5 deg
Refresh rate (per axis)	Threshold: 2 Hz, Goal: 8 Hz
Data Latency	Real time (5 sec)

ID: 4052

2.10.4.2 Particle sensors

ID: 4053

The SEISS particle sensors shall monitor the proton, electron, and heavy ion fluxes at geosynchronous orbit.

ID: 4054

Discussion: These particle fluxes roughly consist of three components: 1) a geomagnetically trapped and highly variable population of electrons and protons 2) sporadic fluxes of electrons, protons, and heavy ions of direct solar origin and 3) the galactic cosmic background. Knowledge of the near-Earth energetic particle environment is important in establishing the natural radiation hazard to humans at high altitudes and in space, as well as risk assessment and warning of episodes of surface charging, deep dielectric charging, and single event upsets of satellite systems. Energetic particle precipitation into the Earth's ionosphere also causes disturbance and disruption of radio communications and navigation systems. These impacts may be mitigated by early warnings of high flux episodes.

ID: 4055

The particle sensors include a magnetospheric particle sensor (MPS), an energetic heavy ion sensor (EHIS), and a solar and galactic proton sensor (SGPS). The particle sensors shall be located on a satellite with a magnetometer.

ID: 4056

The observational parameters and requirements for all particle sensors listed in the GOES Magnetospheric Particle Sensor Requirements Table, the GOES Solar and Galactic Proton Sensor Requirements Table, and the GOES Energetic Heavy Ion Sensor Requirements Table below shall be met.

ID: 4057

Discussion: The energy range of the > 2 MeV electron energy channels has been chosen to provide continuity with prior measurements.

ID: 4058

Noise

ID: 4059

For bands below 30 keV, the total instrument noise (including that from the detector, background, and electronics) shall not exceed 10% of the energy resolution. For bands with threshold energies between 30 keV and 100 keV, noise shall not widen the effective response by more than 10 keV. For bands above 100keV, noise shall not widen the effective response by more than 10% of a band's threshold energy.

ID: 4060

Stability

ID: 4061

The electronic thresholds defining the energy band edges shall not change by more than 3% over the predicted operating conditions.

ID: 4062

In-flight Calibration

ID: 4063

An in-flight calibration mode shall be provided to verify basic instrument operation and to determine the value of energy band edges.

ID: 4064

Electronic discriminator levels shall be determined to ±3%.

ID: 4065

Discussion: Previous experience has indicated that the calibration mode, which is both self-terminating and able to be terminated by ground command, is needed.

ID: 4066

Ground Calibration

ID: 4067

Full instrument calibration is required before launch. NIST assets will be brought to bear as appropriate.

ID: 4069

The energy-dependent responses and the directional responses of the instruments shall be determined for energies ranging from the detector's low-energy threshold to energies for which the particle flux is below the instrument detection threshold, assuming particle flux levels given by the specified maximum particle fluxes.

ID: 4070

Discussion: Calibration can be performed by using a combination of accelerators and/or nuclear sources.

ID: 4071

Contaminants

ID: 4072

The response of the data channels to particles out-of aperture or of a different species or energy shall be less than 10% of the in-band particles.

ID: 4073

Correction algorithms for out-of-band response may be provided if necessary to comply with the out of band response requirement.

ID: 4074

Radiation damage

ID: 4075

Steps shall be taken to minimize and/or mitigate the effects of radiation damage on the instrument system during the lifetime.

ID: 5781

GOES Magnetospheric Particle Sensor Requirements

Observational parameter		Requirement
Low energy electrons and protons	Measurement range	Electrons and Protons: 30 eV - 30 keV
	Number of energy bands	Threshold: 15 evenly spaced logarithmic bands, Goal: 20 evenly spaced logarithmic bands (TBS)
	Measurement accuracy	Threshold: 25%, Goal: 10%
	Spatial coverage	Threshold: 5 directions (TBS), Goal: 9 directions (TBS)
	Refresh rate	Threshold: 30 sec, Goal: 10 sec
	Minimum Flux	E is the energy in keV Electrons: Flux [cm^{-2} s^{-1} $sr^{-1}$$keV^{-1}$] = 9. x 10^4 $E^{-1.3}$ Protons: Flux [cm^{-2} s^{-1} sr^{-1} keV^{-1}] = 40. $E^{-0.8}$
	Maximum Flux	E is the energy in keV Electrons: Flux [cm^{-2} s^{-1} $sr^{-1}$$keV^{-1}$] = 1.5 x 10^9 $E^{-1.3}$ Protons: Flux [cm-2 s-1 sr-1 keV-1] = 1.1 x 10^7 $E^{-0.8}$
	Data Latency	1 min
Medium and high energy electrons and protons	Measurement range	Electrons: 30 keV - 4 MeV, Protons: 30 keV - 1 MeV
	Number of energy bands	Threshold: Electrons: 10 evenly spaced logarithmic bands plus 1 integral channel (>2 MeV), Protons: 7 evenly spaced logarithmic bands. Goal: Electrons: 15 evenly space logarithmic bands plus 1 integral channel (>2 MeV), Protons: 10 evenly spaced logarithmic bands.
	Measurement accuracy	Threshold: 25%, Goal: 10%
	Spatial coverage	Threshold: 5 directions, Goal: 9 directions
	Refresh rate	Threshold: 30 sec, Goal: 10 sec
	Minimum Flux	E is the energy in keV Electrons: Flux [cm^{-2} s^{-1} $sr^{-1}$$keV^{-1}$] = 1.2 x 10^7 $E^{-2.8}$ Protons: Flux [cm^{-2} s^{-1} $sr^{-1}$$keV^{-1}$] = 8. x 10^2 $E^{-1.8}$
	Maximum Flux	E is the energy in keV Electrons: Flux [cm^{-2} s^{-1} $sr^{-1}$$keV^{-1}$] = 2.3 x 10^{11} $E^{-2.8}$

		Protons: Flux $[cm^{-2}\ s^{-1}\ sr^{-1} keV^{-1}] = 5 \times 10^{7}\ E^{-1.3}$
	Data latency	1 min

ID: 4085

2.10.4.2.1 GOES Solar and Galactic Proton Sensor Requirements

Observational parameter	Requirement
Measurement range	Threshold: 1 MeV - 500 MeV Goal: 1 MeV - 500 MeV, and >500 MeV (see bands)
Number of energy bands	Threshold: 10 evenly spaced logarithmic bands , Goal: 15 evenly spaced logarithmic bands plus one integral for > 500 MeV
Measurement accuracy	Threshold: 25%, Goal: 10%
Spatial coverage	2 directions
Refresh rate	Threshold: 1 min, Goal: 30 sec
Data latency	1 min
Maximum flux (E in keV)	Flux $[cm^{-2}\ s^{-1}\ sr^{-1} keV^{-1}] = 2. \times 10^{12}\ E^{-2.8}$
Minimum flux (E in keV)	Flux $[cm^{-2}\ s^{-1}\ sr^{-1} keV^{-1}] = 8. \times 10^{2}\ E^{-1.8}$

ID: 4114

2.10.4.2.1.1 GOES Energetic Heavy Ion Sensor Requirements

Observational parameter	Requirement
Measurement range	10 MeV/nucleon - 200 MeV/nucleon, 4 mass groups: He, C-N-O, Ne-S, and Fe
Number of energy bands	Threshold: 5 evenly spaced logarithmic bands, Goal: 7 evenly spaced logarithmic bands (TBS)
Measurement accuracy	Threshold: 25%, Goal: 10% (TBS)
Spatial coverage	1 direction (TBS)
Refresh rate	5 min (Consecutive measurements may be summed for more massive species)
Data latency	5 min
Maximum flux	Flux $[cm^{-2}\ s^{-1}\ sr^{-1}\ (MeV/nuc)^{-1}] = 5 \times 10^{4}\ (E/nuc)^{-2.3}$ (E in MeV)

Minimum flux	Threshold: Flux [cm^{-2} s^{-1} sr^{-1} $(MeV/nuc)^{-1}$] = 1.1 x 10^{-2} $(E/nuc)^{-1}$ Goal: Flux [cm^{-2} s^{-1} sr^{-1} $(MeV/nuc)^{-1}$] = 2.7 x 10^{-3} $(E/nuc)^{-1}$

ID: 4143

2.10.4.3 X-Ray Sensor (XRS)

ID: 4144

The XRS shall detect the beginning, duration, and magnitude of solar X-ray flares.

ID: 4145

Discussion: The primary function of the XRS is to provide a means of detecting the beginning, duration, and magnitude of solar X-ray flares.

ID: 4146

The XRS shall monitor the disk (40 armin)-integrated solar flux as described in the GOES Solar X-ray Sensor Requirements Table below.

ID: 4147

Discussion: X-ray flares affect HF communications at Earth and are a key indicator of potential geoeffective solar activity. Detected solar flares are classified according to their peak fluxes in the 0.1 - 0.8 nm channel: class C, M, and X corresponds to peak fluxes of 1, 10, and 100 x 10^{-6} W m^{-2}, respectively.

ID: 4148

The instrument shall be sensitive enough to permit quiet sun background measurements at low levels of solar activity while detecting events at the lowest practicable threshold for early event warning.

ID: 4149

The observational parameters and requirements for the XRS, listed in the GOES Solar X-ray Sensor Requirements Table, shall be met.

ID: 4150

The minimum performance of the XRS shall not be compromised by the presence of the anticipated worst-case natural electron environment.

ID: 4151

The out-of-band rejection shall be such that < 10% of the observed signal comes from out-of-band, or some method of monitoring the out-of-band signal shall be provided.

ID: 5990

The signal level shall be such that at minimum (threshold) flux levels, the mean signal shall be greater than the standard deviation of the data (instrumental noise) over a 10-minute interval.

ID: 6352

The instrument reponsivity of the XRS across its FOV shall be uniform to within +/- 5% (threshold) and 2% (goal).

ID: 4152

ID: 4154

2.10.4.3.1 GOES Solar X-ray Sensor Requirements

Observational parameter	Requirement
Spectral range	0.05 - 0.8 nm
Number of channels	2, XRS-A: 0.05 - 0.4 nm XRS-B: 0.1 - 0.8 nm
Measurement range	Threshold: XRS-A: 5 x 10^{-9} - 5 x 10^{-4} W m-2 XRS-B: 2 x 10^{-8} - 2 x 10^{-3} W m-2 Goal: XRS-A: 1 x 10^{-9} - 1 x 10^{-3} W m-2 XRS-B: 1 x 10^{-8} - 4 x 10^{-3} W m-2
Flux Resolution	Threshold: +/- 2%, Goal: +/- 1%
Measurement accuracy	Threshold: 10%, Goal: 5%
Spatial coverage	Solar disk (40 arcmin)
Pointing Knowledge	+/- 2 arcmin
Refresh rate	Threshold: 3 sec, Goal: 0.5 sec
Data latency	3 sec
Long-term stability	< 5% over mission duration
Continuity	No gaps
Wavelength Knowledge	+ / - 5% (prior to launch)

ID: 4195

2.10.4.4 Extreme Ultraviolet Sensor (EUVS)

ID: 4196

The EUVS shall monitor the solar EUV flux in the 5 - 127 nm range.

ID: 6068

Long-term stability of the instrument measuring the EUV flux over the life of the mission shall not exceed the numbers in the table below.

ID: 4197

Discussion: Solar variability at these wavelengths is one of the primary drivers of thermospheric/ionospheric variability, which in turn affects radio communication, navigation, and satellite drag. Uncertainties in the solar EUV flux are a major source of errors in specification and modeling of the thermosphere and ionosphere.

ID: 4198

The observational parameters and requirements for the EUVS, listed in the GOES Solar EUV Sensor Observational Requirements Table, shall be met.

ID: 4199

The minimum performance of the EUVS shall not be compromised by the presence of the anticipated worst-case natural electron environment.

ID: 4200

The out-of-band rejection shall be such that < 10% of the observed signal comes from out-of-band. If the out of band signal is >10%, then a means of measuring and tracking this out of band signal shall be provided.

ID: 6351

The instrument reponsivity of the EUVS across its FOV shall be uniform to within +/- 5% (threshold) and 2% (goal).

ID: 4201

ID: 6046

Full instrument calibration is required before launch. NIST assets will be brought to bear as appropriate.

ID: 4202

.

ID: 4203

2.10.4.4.1 GOES Solar EUV Sensor Observational Requirements

Observational parameter	Requirement
Spectral range	5 - 127 nm
Spectral Resolution	
From 5 to 35 nm	10 nm
From 35 to 115 nm	40 nm
From 118 to 127 nm	10 nm
Flux Resolution	0.25%
Minimum Flux	0.1x solar minimum
Maximum Flux	10x solar maximum
Measurement accuracy	Threshold: 10%, Goal: 5%
Spatial coverage	Solar disk (40 arcmin)
Pointing Knowledge	+/- 2 arcmin
Refresh rate	Threshold: 30 sec, Goal: 10 sec
Data latency	Threshold: 30 sec, Goal: 10 sec
Long-term stability	Threshold: < 5% over mission, Goal: < 2% over mission
Wavelength Knowledge	specified to +/- 5%
Continuity	No gaps

ID: 4241

2.10.4.5 Solar X-Ray Imager (SXI)
ID: 4242

The SXI shall provide a broadband imaging in the soft X-ray to EUV wavelength range.

ID: 4243

The SXI shall provide full-disk solar images at high cadence.

ID: 4244

Discussion: Available combinations of exposures and filters allows the autonomous coverage of the entire dynamic range of solar X-ray features, from coronal holes to X-class flares, as well as the estimate of temperature and emission measure. The operational goals are to: locate coronal holes for geomagnetic storm forecasts, detect and locate flares for forecasts of solar energetic particle (SEP) events related to flares, monitor changes in the corona that indicate coronal mass ejections (CMEs), detect active regions beyond east limb for F10.7 forecasts, and analyze active region complexity for flare forecasts.

ID: 4245

The observational parameters and requirements for the SXI, listed in the GOES Solar X-ray Imager Observational Requirements Table, shall be met.

ID: 4246

Discussion: Because improved capabilities are under discussion for this instrument compared to the original SXI, it has been called Extended SXI (ESXI)

ID: 6009

The SXI shall enable the retrieval of the Differential Emission Measure (DEM) as specified in the table below.

ID: 6010

Model Differential Emission Measures for Solar Features (See Note)

		Coronal Hole		Quiet Corona		Active Region		Flare	
	T	DEM	Error	DEM	Error	DEM	Error	DEM	Error
	5.5	20.29	±0.342	20.30	±0.342	20.50	±0.342	21.70	±0.342
	5.6	20.33	±0.301	20.20	±0.301	20.40	±0.301	21.70	±0.301
Objective	5.7	20.36	±0.255	20.20	±0.255	20.40	±0.255	21.70	±0.255
	5.8	20.36	±0.204	20.30	±0.204	20.50	±0.204	21.70	±0.204
	5.9	20.32	±0.146	20.40	±0.146	20.60	±0.146	21.75	±0.146
Threshold	6.0	20.28	±0.146	20.70	±0.079	20.80	±0.079	21.80	±0.079
	6.1	20.20	±0.146	20.90	±0.079	21.00	±0.079	21.90	±0.079
	6.2	20.00	±0.146	20.80	±0.079	21.20	±0.079	22.00	±0.079
	6.3	19.70	±0.204	20.50	±0.079	21.30	±0.079	22.10	±0.079
	6.4	19.20	±0.255	20.10	±0.079	21.30	±0.079	22.25	±0.079
	6.5	18.50	±0.301	19.70	±0.146	21.10	±0.079	22.40	±0.079
	6.6	N/A	N/A	19.20	±0.204	20.80	±0.079	22.55	±0.079
	6.7	N/A	N/A	18.60	±0.255	20.30	±01.46	22.70	±0.079
	6.8	N/A	N/A	N/A	N/A	19.50	±0.204	22.95	±0.079
	6.9	N/A	N/A	N/A	N/A	18.50	±0.255	23.15	±0.079
	7.0	N/A	N/A	N/A	N/A	N/A	N/A	23.20	±0.079

7.1	N/A	N/A	N/A	N/A	N/A	N/A	23.15	±0.146
7.2	N/A	N/A	N/A	N/A	N/A	N/A	22.95	±0.204
7.3	N/A	N/A	N/A	N/A	N/A	N/A	22.65	±0.255
7.4	N/A	N/A	N/A	N/A	N/A	N/A	22.10	±0.301
7.5	N/A	N/A	N/A	N/A	N/A	N/A	21.50	±0.342

Note: Base 10 logarithmic values of parameters are given.

DEFINITIONS:

Temperature

Temperature is defined in Kelvin. The Table gives the base 10 logarithmic value of the temperature grid for DEM evaluation. The grid is evenly spaced in the logarithmic domain. The threshold range covers T = 1 to 10 MK ($\mathrm{Log}_{10}(T)$=6.0 to 7.0). The goal range covers from T = 0.5 to 20 MK ($\mathrm{Log}_{10}(T)$=5.7 to 7.3). Grid bins may be considered to be evenly spaced in the logarithmic domain, e.g., the bin centered on $\mathrm{Log}_{10}(T)$=6.5 would begin at $\mathrm{Log}_{10}(T)$=6.45 and end at $\mathrm{Log}_{10}(T)$=6.55.

Differential Emission Measure

The differential emission measure used here is the column emission measure per unit temperature as defined by:

$$DEM_C = \int \frac{n_e^2}{dT} dx$$

where n_e^2 is the electron number density in units of cm^{-3}, dT is the temperature differential in units of Kelvin (K), x is the line of sight integration path in units of cm. Thus, DEM_C has units of cm^{-5}-K^{-1}. Integration of DEM_C over temperature yields the column emission measure. The Table gives the base 10 logarithmic value of the DEM_C to be evaluated on the temperature grid given.

Error

The error allowable in the final retrieval of DEM information is per pixel and is defined in terms of a multiplicative error factor, e.g., a 20% error represents an error factor of 1.2. The base 10 logarithm of this error factor is given in the Table. For an error factor of 1.2, we have Log_{10}(Error)=0.079, which is *additive* in the logarithmic domain. For example, if $\mathrm{Log}_{10}(DEM_C)$=21.5 ±0.146, then the uncertainty of the final DEM determination is allowed to range from $\mathrm{Log}_{10}(DEM_C)$=21.354 to 21.646.

The plasma DEM and temperature are related to the radiance, R, as follows:

$$R = \frac{1}{4\pi} \int_T \int_\lambda DEM_C(T) F(\lambda, T) dT d\lambda$$

where F is the (photon) spectral emissivity per electron (cm^3 Å^{-1} s^{-1}). Thus, radiance is in units of cm^{-2} sr^{-1} s^{-1}. This can also be expressed as cm^{-2} arcsec^{-2} s^{-1}, in which case the incident photon rate on an SXI detector pixel, I_{pix}, would be computed as:

$$I_{pix} = \frac{\Omega}{4\pi} \int_T \int_\lambda DEM_C(T) F(\lambda, T) A_{eff}(\lambda) dT d\lambda$$

where Ω is the solid angle subtended by a detector pixel and A_{eff} is the instrument effective area as a function of wavelength. The units of the incident photons are counts per second. With the TBS spectral model, the above equations can be represented in terms of energy (ergs) rather than photons (counts).

Different technical approaches are possible such as the two examples described below. Option A represents a possible set of broad, soft X-ray bands. Option B represents a set of narrow, extreme ultraviolet bands. Bands for each option are provided in the following table.

Potential Spectral Bands

	Option A		Option B	
Band	Approximate Wavelength (nm)	Peak Response Log(T)	Wavelength (nm)	Approx. Peak Response Log(T)
A	0.6-10.0 nm	6.3	17.45 (Fe X)	5.9
B	0.6-8.0 nm	6.4	21.10 (Fe XIV)	6.3
C	0.6-5.0 nm	6.5	33.50 (Fe XVI)	6.5
D	0.6-2.0 nm	6.7	9.40 (Fe XVIII)	6.9
E	0.6-1.6 nm	6.8	19.30 (Fe XII & XXIV)	6.1 & 7.5
F	0.6-1.2 nm	7.0	13.10 (Fe VIII & XX)	5.7 & 7.2

The temperature response of Option A is broad while the temperature response of Option B is narrow. Thus, while the peak response of Option A may not be at LogT=6.0, substantial response still exists at that temperature.

The selected bands and response shall allow the reconstruction of DEM curves shown above, modeled for different solar features, to be accomplished from LogT=5.7 to LogT=7.2 with the uncertainties specified. DEM reconstruction will be accomplished using the hybrid abundances of Fludra and Schmelz (The absolute coronal abundances of sulfur, calcium, and iron from Yohkoh-BCS flare spectra, *Astronomy and Astrophysics*, *348*, 286-294, 1999), the ionization equilibrium of Mazzotta et al. (Ionization balance for optically thin plasmas: Rate coefficients for all atoms and ions of the elements H to NI, *Astronomy and Astrophysics Supplement Series*, *133*, 403-409, 1998), and the TBS spectral model. If one of the two examples above is not employed, DEM reconstruction uncertainties shall be computed using Monte Carlo simulation with a noise model of appropriate fidelity, e.g. including photon statistics, detector read noise, etc. An appropriate curve-fitting algorithm (TBS) will be used to obtain a smooth DEM reconstruction.

ID: 4247

2.10.4.5.1 GOES Solar X-ray Imager Observational Requirements

Observational parameter	Requirement
Spatial coverage	0 - 1.3 solar radii
Spatial/Angular resolution	See next table (below)

Pointing/"Mapping" accuracy	Stability during 24 hours: +/- 1.0 arcmin (N-S, E-W), Stability during exposure: +/- 2.0 arcsec (E-W) (THRESHOLD) and +/- 2.0 arcsec (N-S) (THRESHOLD) and +/- 1.0 arcsec (E-W) (GOAL) and +/- 1.0 arcsec (N-S) (GOAL) Control: +/- 15.0 arcsec +/- 3 arcmin of sun center
Pointing Knowledge / Mapping uncertainty	+/- 2.5 arcsec
Measurement range	Threshold: Radiance: 0.3 - 106 (TBR) photons s^{-1} cm^{-2} $arcsec^{-2}$ Temperature: 1 - 10 MK (TBS); Goal: Radiance: 0.3 - 10^6 photons s^{-1} cm^{-2} $arcsec^{-2}$ Temperature: 0.5 - 20 MK (TBS)
Measurement resolution	Threshold: Radiance: 0.1% (TBS) Goal: Radiance: 0.1%, (TBS)
Measurement accuracy	Threshold: 20% in radiance, Goal: 10% in radiance
Refresh rate	Threshold: Imaging: < 2 min, Temperature: < 6 min Goal: Imaging: < 1 min, Temperature: < 3 min
Product latency*	< 1 min
Long-term stability	20%
Reliability/Continuity	No gaps > 2 min

ID: 6018

* Product latency is defined as the time from the end of data collection to the end of product generation. Forty seconds of the latency is required for processing the data at SEC.

ID: 6011

The SXI shall meet the spatial resolution requirements of the following table. The point response shall be uniform to ±30% across the entire field of view (THRESHOLD). As a GOAL, the point response shall be uniform to ±10%.

ID: 6012

Point Response Requirement in Terms of Encircled Energy

Encircled Energy	Threshold Diameter (arc sec)	Goal Diameter (arc sec)
37%	7	5

66%	14	10
75%	21	15
85%	35	25
99% (TBS)	56	40

ID: 6013

Discussion: The spatial/angular resolution is has been written in terms of the encircled energy requirement.

ID: 4291

Discussion: Refresh rate for 'imaging' refers to full measurement range coverage in a single bandpass filter. This may consist of multiple images with different exposures. Refresh rate for temperature assumes that full measurement range data in at least three bandpass filters is required for temperature retrieval.

ID: 4292

Spacecraft Housekeeping data shall be supplied in real time in conjunction with the SXI data.

ID: 4293

Discussion: Examples include flagging spacecraft or other instrument operations that adversely affect SXI performance such as blackbody calibration and calibration of other instruments.

ID: 4294

Time tagging of SXI data shall be synchronized with Universal Time within 1.0 msec.

ID: 4295

Discussion: SXI images should be taken at a regular cadence with a phase drift of no more than 1.0 second per day. The need to precisely phase SXI images should not preclude the ability to simply take images at a faster or slower pace. Images must be downlinked in the order taken.

ID: 6047

Full instrument calibration is required before launch. NIST assets will be brought to bear as appropriate.

ID: 4296

2.10.4.6 Solar coronagraph (SCOR)

ID: 4297

This instrument is currently envisioned as a part of pre-planned product improvement (P^3I).

ID: 4298

The SCOR shall provide white light imagery of the inner corona at a high cadence, with the aim of determining the speed, direction, and spatial extent of detected CMEs.

ID: 4299

Discussion: The primary function of the Solar COROnagraph (SCOR) is early detection of coronal mass ejections (CMEs). CMEs are one of two main drivers of geomagnetic storms and the main driver of the largest storms. The coronagraph will provide one to three day warnings of geomagnetic storms.

ID: 4300

The observational parameters and requirements for the coronagraph, listed in the GOES Solar Coronagraph Observational Requirements Table, shall be met.

ID: 4301

Note: The instrument passband will be chosen to lie within the listed spectral range.

ID: 4302

2.10.4.6.1 GOES Solar Coronagraph Observational Requirements

Spectral band	5000 - 8000 Å (TBD, see note above).
Spatial coverage	Threshold: 3.7 - 17 solar radii (0.93 - 4.25 deg halfwidth), Position angle: > 355 deg Goal: 2 - 17 solar radii (0.5 - 4.25 deg halfwidth), Position angle: 360 deg
Spatial resolution	50 arcsec (TBS)
Pointing accuracy	+/- 1 arcmin of sun center
Mapping accuracy / Pointing stability	6.25 arcsec during image sequence (TBS) (Note this value varies with spatial resolution).
Mapping uncertainty / Pointing Knowledge	Threshold: 25 arcsec, Goal: 12.5 arcsec (TBS)
Measurement range	Threshold: 1×10^{-11} - 1×10^{-8} B/B_{Sun} (TBS), where Bsun is the mean solar brightness. Goal: 1×10^{-11} - 5×10^{-8} B/B_{Sun} (TBS), where Bsun is the mean solar brightness.
Measurement resolution	Threshold: 5×10^{-11} B/B_{Sun} inner, 1×10^{-12} B/B_{Sun} outer, where B_{sun} is the mean solar brightness Goal: 1×10^{-11} B/B_{Sun} inner, 1×10^{-12} B/B_{Sun} outer, where B_{sun} is the mean solar brightness
Measurement accuracy	Threshold: 25%, Goal: 10%
Refresh rate	15 min

Product latency*	7 min (Threshold), 1 minute (Goal)
Stray Light	Threshold: 5 x 10^{-12} B/B_{sun} Goal: 1 x 10^{-12} B/B_{sun}
Reliability/Continuity	Threshold: No gaps > 30 min, Goal: No gaps

ID: 4340

* Product latency is defined as the time from the end of data collection to the end of product generation. Forty seconds of the latency is required for processing the data at SEC.

ID: 6048

Full instrument calibration is required before launch. NIST assets will be brought to bear as appropriate.

ID: 6014

ID: 4341

2.10.5 Remaining Spacecraft Resources

ID: 4342

Any remaining space in the satellite that fits into the remaining spacecraft allocations, after all of the other instruments and communications are accommodated, will be allocated to additional P^3I resources.

ID: 4343

2.10.6 GOES Lightning Mapper (GLM)

ID: 4344

The GOES Lightning Mapper (GLM) is now classified as an operational instrument.

ID: 4345

The GLM will meet the following GPRD-1fd requirement (the MRD requirement follows this paragraph listed for traceability):

ID: 4346

The GLM shall map all forms of lightning discharges over the hemisphere, CONUS, and mesoscale with the following requirements: 10 km horizontal spatial resolution (THRESHOLD) and 1 km (GOAL); vertical resolution from the surface to the cloud top; with 5 km mapping accuracy (THRESHOLD) and a 0.100 km (GOAL); with real time measurements range; 70-90% probably of detection (THRESHOLD) with 99% (GOAL); with continuous refresh; and 1 minute latency (THRESHOLD) or 10 sec (GOAL) latency to the level 1 b product.

ID: 4347

General comments

ID: 4348

A GOES Lightning Mapper will be a new tool for NOAA. In addition to the nowcasting component, the data would be assimilated into models. It would have the potential to increase tornado warning lead times, improve lightning danger alerts by providing information on storm intensification, and enable disaster teams to be ready and on site sooner. Better lightning detection would provide economic benefits for airplane safety, passenger comfort, and route optimization. A long-term database of such lightning data would provide information on lightning to track any decadal changes. *

The lightning measurements will be related on a continuous basis to other observable data, such as radar returns, cloud images, and other meteorological variables.

ID: 4349

GLM requirements

ID: 4350

THE GLM shall continuously detect lightning over the full disk view of the earth as seen from the satellite location. The full disk covers nominally 17.76 degrees, with the exception of limb darkening effects. The full disk includes the CONUS and the mesoscale.

ID: 4351

Discussion: Lightning must be detected from all of the areas listed above all of the time, not by scanning the entire full disk area and sampling only a portion of it at one time and another portion at a later time.

ID: 4352

The spatial resolution shall be 10 km (THRESHOLD) with a 1 km (GOAL) at the satellite sub point (SSP).

ID: 4353

Discussion: Lightning will illuminate the entire cloud but there is a need to sample at a 4 km spatial resolution in order to better identify the location of the storm cells.*

ID: 4354

Lightning shall be detected over a vertical range from the surface to the cloud top. This shall include detection of lightning in the vertical column.

ID: 4355

Discussion: Distinguishing between the various types of lightning (cloud-to-ground versus cloud-to-cloud) is not required.

ID: 4356

The navigation error shall be less than 1/2 of the angular equivalent of the horizontal spatial resolution (TBR) (THRESHOLD) with a < 6 urad (TBR) (GOAL).

ID: 4357

The frame to frame registration error shall be < 35 urad (TBR) (THRESHOLD) with a < 6 (TBR) urad (GOAL) over 1 second.

ID: 4358

The probability of flash detection shall be 70 % (THRESHOLD) and 99% (GOAL).

ID: 4359

The data must be delivered in TBS seconds to the ground to allow for all processing to be completed to meet the 1 minute latency to the level 1b.

ID: 4360

The GLM shall detect lightning flashes, which can occur with a 1ms duration.

ID: 6066

Full instrument calibration is required before launch. NIST assets will brought to bear as appropriate

ID: 4361

2.10.7 Geo-Microwave

ID: 4362

The GOES Microwave Imager/Sounder (GEM or GMS) is currently planned as pre-planned product improvement (P^3I) See section 2.11.4 for that definition. **The microwave instrument will perform the following measurements required by the GPRD-1fd. Goal values are currently listed in Appendix A.**

ID: 4363

The microwave instrument will ***measure*** the Vertical Temperature profile through the clouds. The spatial resolution will be reduced from that of the infrared sounder (see section (2.10.2) 2A).

ID: 4364

The microwave instrument will ***measure*** the Vertical Moisture profile through the clouds. The spatial resolution will be reduced from that of the infrared sounder (see section (2.10.2) 2A).

ID: 4365

The microwave instrument will ***measure*** the Capping Inversion profile through the clouds. The spatial resolution will be reduced from that of the infrared sounder (see section (2.10.2) 2A).

ID: 4366

The microwave instrument will ***measure*** the Moisture Flux profile through the clouds. The spatial resolution will be reduced from that of the infrared sounder (see section (2.10.2) 2A).

ID: 4367

The microwave instrument will ***contribute to*** the Imagery, All Weather, Day and Night. The spatial resolution will be reduced from that of the infrared imager and the infrared sounder.

ID: 4368

The microwave instrument will ***contribute to*** Hail Detection over the Hemisphere, CONUS, and Mesoscale but at degraded spatial resolution.

ID: 4369

The microwave instrument will ***contribute to*** Precipitation Type and Rate over the Hemisphere, CONUS, and Mesoscale but at degraded spatial resolution.

ID: 5841

The microwave instrument will ***contribute to*** Rainfall Potential over the Full Disk but at degraded spatial resolution.

ID: 4370

The microwave instrument will ***measure*** the Total Water Content. The spatial resolution will be 100 km (THRESHOLD) on the Hemisphere, 25 km on the CONUS (THRESHOLD), and 25 km on the mesosphere (THRESHOLD) over a measurement range of 0-10 kg/m^3 with a measurement accuracy of +/- 10% and a coverage time of 3 hours for the hemisphere, 1 hour for CONUS, and 15 minutes for the mesoscale. The data latency will be 60 minutes for the hemisphere, 10 minutes for CONUS, and 10 minutes for the mesoscale.

ID: 4371

The microwave instrument will measure the Tropical Cyclone Inner Core Vertical Temperature Profile to address the following details of the threshold requirement for the Tropical Cyclone Inner Core Vertical Temperature Profile: over the full disk and hemisphere, with a threshold 60 minute refresh; with a 3 minute threshold latency; at 10 km threshold resolution; using the temperature sounding of 10 ; using 2 km mapping uncertainty; over the range of 210 to greater than 300 K employing the following layering specified by NOAA's NWS---from the surface to 500 mbar, +/- 1 K from 500 to 300 mbar, and +/- 1K from 300 to 100 mbar; and with +/- 1 K precision.

ID: 4372

The microwave instrument will measure Sea Surface Winds through a polarization measurement to address the following details of the threshold requirement for the Sea Surface Winds determination: over the full disk and hemisphere, with a threshold 60 minute refresh, with a 3 minute threshold latency, at 10 km threshold resolution by using the moisture and temperature sounding of 10 , using 0.5 km mapping uncertainty for ABI, and over the range of 0 - 150 knots, and with +/- 5 knots accuracy.

ID: 5840

The microwave instrument will measure Sea Surface Winds: Mesoscale through a polarization measurement to address the following details of the threshold requirement for the Sea Surface Winds determination: over the 1000 km by 1000 km mesoscale with a threshold 60 minute refresh, with a 15 minute threshold latency, at 10 km threshold resolution (TBR) by using the moisture and temperature sounding vertical resolution of 10 km , using 5.0 km mapping uncertainty for ABI, and over the range of 0 - 50 m/sec, and with +/- 1 m/sec accuracy.

ID: 4373

The microwave instrument will ***contribute*** to Coastal Sea Surface Winds (inside the EEZ) to address the following details of the threshold requirement for the Coastal Sea Surface Winds (inside the EEZ); with a threshold 60-minute refresh, a 3-minute latency, at 10.0 km. threshold resolution, using TBD km mapping uncertainty, over the ranges of 0 to 150 knots, with +/- 1-knot accuracy.

ID: 4374

The GOES Microwave Sensor (GMS) will have one of several forms. A 6 band, multi-channel radiometer is described here. A phased array similar to the GEOStar array of JPL (a 3 band instrument) and other forms of the microwave instruments are also being considered. The requirements for the six-band radiometer are described here, although other types of coverage are not excluded. As described in Section (2.10.2) 3.B.2.g of the HES, temperature and water vapor information can be obtained from several spectral regions of the atmosphere in the infrared and several examples are listed in that section. In a parallel sense, the band coverage listed below is an example of microwave spectral coverage that then can yield temperature and water vapor retrievals, in combination with clear window coverage.

ID: 4375

The GMS will provide time-resolved precipitation imagery and atmospheric vertical temperature and water vapor profiles through many types of cloud cover. The instrument, defined by the table below, uses frequencies from 50 GHz through 425 GHz to provide equatorial horizontal spatial resolution (after post-processing) of ~12 km.

ID: 4376

Parabolic Microwave radiometer

ID: 4377

A baseline design for GMS employs a 2-m reflector in a symmetric Cassegrain configuration with a small (~15 cm) scanning subreflector. The subreflector is capable of rapid angular rotation to effect a small amount of beam scan, along with translation to compensate for changes in focal length of the main reflector due to temperature induced distortions. Receivers are located behind the main reflector and use a third reflector (also behind the main reflector) that rotates to permit the receivers to view either the Earth (via the main reflector), one of two warm calibration targets, or cold space (also for calibration).

ID: 4378

Based on estimates for receiver performance, the scan time for an approximate CONUS area (3000 km x 5000 km) is 90 minutes. For regional areas (1500 km x1500 km) the scan time decreases to ~15 minutes. The overall scan time is anticipated to decrease somewhat with expected improvements in receiver components.

ID: 6067

Full instrument calibration is required before launch. NIST assets will brought to bear as appropriate

ID: 4379

2.10.8 Communications

ID: 4380

Note: This section described the space-located communication for the GOES-R system. The relocation of these services, other than telemetry and command, to a commercial satellite or a dedicated satellite is being considered.

ID: 4381

2.10.8.1 Satellite Services

ID: 4382

2.10.8.1.1 Telemetry and Command

ID: 4383

The GOES-R satellite is required to support telemetry and command of the spacecraft. This system interfaces with the terrestrial components described below:

ID: 4385

> The NOAA Command and Data Acquisition Station (CDAS) and the backups described in section 3.3 and the associated NOAA Satellite Operations Control Center (SOCC) become the primary telemetry interface during normal on-orbit operation.

ID: 4384

> The NASA Deep Space Network (DSN) or similar system: This interface is primary during the launch and orbit raising phases of the mission.

ID: 4386

The A, B, and C (C is P^3I) spacecrafts described in the space-located segment will support this capability.

ID: 4387

2.10.8.1.2 Sensor Data Downlink

ID: 4388

The Sensor Data (SD) link is a primary data link that includes all spacecraft components required for the downlink transmission of the combined (multiplexed) on-board instrument data to the NOAA Command and Data Acquisition Station (CDAS).

ID: 4389

The Sensor Data (SD) link provides for the transmission of all sensor data in a multiplexed format to the designated NOAA CDAS. This link shall have the following basic characteristics:

ID: 4390

Data Content Instrument data from the ABI, HES, GMS (P^3I), GLM, SIS, SEISS, and SCOR (P^3I), and selected telemetry functions. Specific components depend on spacecraft:

ID: 4391

A Satellite: ABI, SIS, GLM

ID: 4392

B Satellite: HES (including MFGS), SEISS

ID: 4393

(P^3I), possibly C satellite: GMS, SCOR (SCOR location TBR)

ID: 4394

Data Rate The multiplexed instrument data rate for the satellites are:

ID: 4395

A Satellite: 65 Mbit/s (approx., TBR)

ID: 4396

B Satellite: 67 Mbit/s (approx., TBR)

ID: 4397

(P^3I), possibly C satellite: ~ 2 Mbit/(approx., TBR)

ID: 4398

Data Format Compatible with CCSDS recommendations

ID: 4399

Error Control As applied by the C&DH subsystem

ID: 4400

Required BER $1 \cdot 10^{-9}$ at 99.9% link availability (threshold), worst month (TBR); $1 \cdot 10^{-10}$ at 99.9% link availability (goal), worst month (TBR)

ID: 4401

RF Bandwidth (See appendix B)

ID: 4402

X-Band downlink (see appendix B for numeric bandwidths)

ID: 4424

Coverage	Primary and backup CDAS from 75º W, 90º W (check-out), 105º W (storage and operations (TBS)) and 135 (TBS)º W satellite. For GOES East (75º W) the primary CAD's is located at Wallops Island, VA with a backup at GSFC. For . For West (135º W (TBS)) the primary CDAS is located at Wallops Island, VA with a backup at Fairbanks, AK. For GOES-R Central (P^3I) (105º W) the primary and backup CDAS are TBS.

Discussion: It is relevant to note that Siberia has much more stringent PFD requirements than Alaska and this has to be considered in the design of the SD antenna beamshape.

ID: 4425

The A, B, and C (C is P^3I) spacecrafts described in the space-located segment will support this capability.

ID: 4426

2.10.8.2 Removed

ID: 4427

2.10.8.3 Payload Services

ID: 4428

2.10.8.3.1 GOES Rebroadcast

ID: 4429

The GOES Re-Broadcast (GRB) transponder supports the processed data distribution from the CDAS to various receive sites including NOAA's NWS, DoD, international users, and research organizations.

ID: 4430

The GOES Re-Broadcast (GRB) transponder supports the rebroadcast of the ground processed weather data from the CDAS to a wide community of NWS and governmental and academic research organizations. This link shall have the following basic characteristics:

ID: 4431

Data Content	Ground processed sensor data similar in content to the current GVAR data (the data content is transparent to the GRB transponder)

ID: 4432

Data Rate	5 Mbit/s total (Threshold) including all overhead (TBR) and 24 Mbps GOAL (TBR) including all overhead.

ID: 4433

Data Format	TBD (the data format is transparent to the GRB transponder)

ID: 4434

Error Control	TBD

ID: 4435

Required BER	1 x 10^{-6} (Threshold) and 1 x 10^{-8} (Goal) at 99.9% availability, worst month (TBR)

ID: 4436

RF Bandwidth	(See appendix B) (TBR).

ID: 4437

RF Band	Uplink: S-Band (TBR, X-Band is being considered) (see appendix B for numeric band frequencies).

ID: 4438

Downlink:	L-Band

ID: 4439

Coverage	Uplink: Primary and backup CDAS from 75º W, 90º W (check-out), 105º W (storage and operations (TBS)). For GOES-R East (75º W) the primary CDAS is located at Wallops Island, VA with a backup at GSFC. For GOES-R West (135º W (TBS)) the primary CDAS is located at Wallops Island, VA with a backup at Fairbanks AK. For GOES-R Central (P^3I) (105º W) the primary and backup CDAS are TBS.

ID: 4440

Downlink:	Earth Coverage to 5º-elevation angle

ID: 4441

The A, B, and C (C is P^3I) spacecraft described in the space-located segment will support this capability.

Discussion: GRB potentially has a higher data rate than the GOES N-Q GVAR service due to the enhanced imagery and sounding capabilities of the GOES R series.

ID: 4442

2.10.8.3.2 Unique Payload Services

ID: 4443

2.10.8.3.2.1 Search and Rescue

ID: 4444

Support is provided to the Cospas-Sarsat System through an on-board Search and Rescue (SAR) transponder that relays received emergency beacon signals to Local User Terminals (LUTs) in the Sarsat system.

ID: 4445

GOES support of the Cospas-Sarsat Search and Rescue (SAR) is provided by an on-board transponder. The system requirements for the GOES-R series will be similar to that of the preceding GOES generations however the downlink to the Local User Terminals (LUT's) will be a direct frequency translation of the uplink band:

ID: 4446

Data Content	Data content is transparent to the transponder

ID: 4447

Data Rate	Transmission is rate 400 bit/s (transponder does not remodulate)

ID: 4448

Data Format	Data format is transparent to the transponder

ID: 4449

Error Control	As present on beacon signal

ID: 4450

Required BER	$1 \cdot 10^{-5}$ at 99.9% availability, worst month (TBR)

ID: 4451

RF Bandwidth	100 kHz (approx., TBR)

ID: 4452

RF Bands	Uplink: UHF

ID: 4453

Downlink:	L-Band

ID: 4454

Coverage	Uplink: Earth Coverage to 5º-elevation angle

ID: 4455

Downlink:	Earth Coverage to 5º-elevation angle

ID: 4456

The A, B, and C (C is P^3I) spacecraft described in the space-located segment will support this capability.

ID: 4457

2.10.8.3.2.2 DCP

ID: 4458

The Data Collection Platforms (DCP) in the Data Collection System (DC is a data link that provides a service. The DCS channel plays a significant role in supporting critical national systems important to the safety of citizens, commerce, shipping, and farming among other things. Data obtained from this service is also widely used by the National Weather Service. Support to the DCS is provided by two satellite transponders. The Data Collection Platform Report (DCPR) transponder supports the link from a large number of small data platforms in the DCS to the CDAS and other Direct Readout Ground Stations (DRGS). The Data Collection Platform Interrogate (DCPI) transponder supports a command link from the CDAS to selected platforms.

ID: 4459

Support to the Data Collection System (DCS) is provided by two satellite transponders. These correspond to (1) the links required for the Data Collection Platforms (DCP's) to provide reported data to the CDAS and other Direct Readout Ground Stations (DRGS) termed Data Collection Platform Report (DCPR) links and (2) an outbound polling link from the CDAS to the DCP's termed the Data Collection Platform Interrogate (DCPI) link.

ID: 6353

In the GOES-R timeframe, the anticipated 89,000 (TBS) total platforms (Threshold) shall be supported, with a goal of 158,000 supported platforms.

ID: 4460

> Discussion: DCS users project a large growth in usage, due to both more platforms and shorter report intervals. Additionally, the NWS estimates the value of DCS to be several billion dollars per year. These factors are likely to drive system loading near the capacity limits of the current DCPR system by the expected GOES R launch date.

ID: 4461

2.10.8.3.2.2.1 Data Collection Platform Report (DCPR)

ID: 4462

The DCPR links originate at any of a large number of DCP's and are supported in the GOES-R satellite by a bent pipe transponder with the following basic interface characteristics. The signals in this transponder are in an FDMA format:

ID: 4463

Data Content — Data content is transparent to the transponder

ID: 4464

Data Rate — Transmission rate 100, 300 or 1200 bit/s, (transponder does not remodulate), although a small number of platforms require data rates as high as 128 kbps.

ID: 4465

Data Format — Data format is transparent to the transponder

ID: 4466

Error Control The error control is transparent to the DCPR transponder

ID: 4467

Required BER $1 \cdot 10^{-6}$ at 99.9% availability, worst month (TBR), $1 \cdot 10^{-7}$ at 99.9% availability, worst month (TBR),

ID: 4468

RF Bandwidth Channelized into 233 channels (200 @ 1.5 and 33 @ 3 kHz) for a total bandwidth of 400 kHz.

ID: 4469

RF Bands Uplink: UHF

ID: 4470

Downlink: L-Band

ID: 6355

Latency for final products: 5 min (threshold), 1 minute (goal)

ID: 4471

Coverage Uplink: Earth Coverage to 5º-elevation angle

ID: 4472

Downlink: Earth Coverage to 5º-elevation angle

ID: 4473

The A, B, and C (C is P^3I) spacecraft described in the space-located segment will support this capability.

ID: 6354

Discussion: Typical platforms support 4 transmission per hour with typical message sizes of 200 - 1000 Bytes. A small number of platforms require transmissions as frequently as every 5 minutes and have messages as large at 30 kBytes

ID: 4474

2.10.8.3.2.2.2 Data Collection Platform Interrogate (DCPI)

ID: 4475

Transmission of the DCPI links from the CDAS to the DCP's is supported in the GOES-R satellite by a bent pipe transponder that must have the following basic interface characteristics:

ID: 4476

Data Content Data content is transparent to the transponder

ID: 4477

Data Rate Transmission is rate 100 bits (transponder does not remodulate)

ID: 4478

Data Format Data format is transparent to the transponder

ID: 4479

Error Control None (TBS)

ID: 4480

Required BER $1 \cdot 10^{-6}$ at 99.9% availability, worst month (TBR)

ID: 4481

RF Bandwidth 5 Hz (approx., TBR)

ID: 4482

RF Bands Uplink: S-Band

ID: 4483

Downlink: UHF

ID: 4484

Coverage Uplink: Primary and backup CDAS from 75º W, 90º W (check-out), 105º W (storage and operations (TBS)). For GOES-R East (75º W) the primary CDAS is located at Wallops Island, VA with a backup at GSFC. For GOES-R West (135º W (TBS)) the primary CDAS is located at Wallops Island, VA with a backup at Fairbanks AK. For GOES-R Central (P^3I) (105º W) the primary and backup CDAS are TBS.

ID: 4485

Downlink: Earth Coverage to 5º-elevation angle

ID: 4486

The A, B, and C (C is P^3I) spacecraft described in the space-located segment will support this capability.

ID: 4487

2.10.8.3.2.3 LRIT

ID: 4488

The Low Rate Information Transmission (LRIT) is an unique digital data link that provides a service. The LRIT transponder supports the transmission of low-resolution satellite imagery from the CDAS to a large number of small receiving sites. This service is an evolution of the existing WEFAX analog facsimile transmission.

ID: 4489

The Low Rate Information Transmission (LRIT) service supports the widespread distribution of relatively low data rate low-resolution satellite imagery from the CDAS to a large number of small receiving sites. Transmission is supported in the GOES-R satellite by a bent pipe transponder that must have the following basic interface characteristics:

ID: 4490

Data Content Data content is transparent to the transponder

ID: 4491

Data Rate Information rate 256 kbit/s, Transmission rate 585 kbit/s (TBR) (transponder does not remodulate)

ID: 4492

Data Format Data format is transparent to the transponder

ID: 4493

Error Control TBS

ID: 4494

Required BER $1 \cdot 10^{-8}$ at 99.9% availability, worst month (TBR)

ID: 4495

RF Bandwidth 600 kHz (approx., TBR)

ID: 4496

RF Bands Uplink: S-Band

ID: 4497

Downlink: L-Band

ID: 4498

Coverage Uplink: Primary and backup CDAS from 75º W, 90º W (check-out), 105º W (storage and operations (TBS)). For GOES-R East (75º W) the primary CDAS is located at Wallops Island, VA with a backup at GSFC. For GOES-R West (135º W (TBS)) the primary CDAS is located at Wallops Island, VA with a backup at Fairbanks AK. For GOES-R Central (P^3I) (105º W) the primary and backup CDAS are TBS.

ID: 4499

Downlink: Earth Coverage to 5º-elevation angle

ID: 4500

The A, B, and C (C is P^3I) spacecraft described in the space-located segment will support this capability.

ID: 4501

2.10.8.3.2.4 EMWIN

ID: 4502

The Emergency Managers Weather Information Network (EMWIN) is an unique data link that provides a service. The EMWIN transponder provides for the transmission of low data rate weather and other emergency related data from the CDAS to Local Emergency Managers of the Federal Emergency Management Agency (FEMA).

ID: 4503

The Emergency Managers Weather Information Network (EMWIN) service supports the widespread distribution of low data rate weather and other emergency related data from the CDAS to small receive only earth stations in the service of Local Emergency Managers of the Federal Emergency Management Agency (FEMA). Transmission is supported in the GOES-R satellite by a bent pipe transponder that must have the following basic interface characteristics:

ID: 4504

Data Content Data content is transparent to the transponder

ID: 4505

Data Rate Information rate 56 kbit/s, Transmission rate is approximately 77 kbit/s (TBR) (transponder does not remodulate)

ID: 4506

Data Format Data format is transparent to the transponder

ID: 4507

Error Control TBS

ID: 4508

Required BER $1 \cdot 10^{-6}$ at 99.9% availability, worst month (TBR)

ID: 4509

RF Bandwidth 160 kHz (approx., TBR)

ID: 4510

RF Bands Uplink: S-Band

ID: 4511

Downlink: L-Band

ID: 4512

Coverage — Uplink: Primary and backup CDAS from 75º W, 90º W (check-out), 105º W (storage and operations (TBS)). For GOES-R East (75º W) the primary CDAS is located at Wallops Island, VA with a backup at GSFC. For GOES-R West (135º W (TBS)) the primary CDAS is located at Wallops Island, VA with a backup at Fairbanks AK. For GOES-R Central (P^3I) (105º W) the primary and backup CDAS are TBS.

ID: 4513

Downlink: Earth Coverage to 5º-elevation angle

ID: 4514

The A, B, and C (C is P^3I) spacecraft described in the space-located segment will support this capability.

ID: 4515

2.11 SATELLITE SYSTEM

ID: 4516

2.11.1 Recovery after Spacecraft Maneuvers

ID: 4517

The spacecraft system shall be capable of performing any maneuvers, including yaw flip, in 1.5 (TBR) hours.

ID: 4518

Discussion: Routine operations should not be re-established too quickly to endanger the health or safety of the instrument.

ID: 4519

Benefits: Excessive delays in resuming routine sounding operations following mandatory outages associated with maneuvers can threaten continuity of weather surveillance and result in degradation of forecasts of severe weather.

ID: 4520

2.11.2 Removed

ID: 4521

2.11.3 Shortfalls in Meeting GEO observational needs

ID: 4522

Some of the GPRD-1fd requirements will not be met by the current instrumentation planned for GOES-R due to finite resources, whether temporal or financial. The contents of this section may change over time with any changes in allocated resources.

ID: 5863

It is important to note that all TBS values listed as GOES-R product requirements are "To Be Supplied by the government". The GOES Program office will maintaining control over the supplied values. Many of these values will require detailed study over the period of several years to assess the capability of the system, particularly when TBS was used for measurement accuracy values.

ID: 4523

2.11.3.1 Full shortfalls

ID: 4524

None.

ID: 4525

2.11.3.2 Partial shortfalls

ID: 4526

The items listed below represent cases where the letter of the description in the GPRD-1fd requirements is not met by the GOES in every parameter but the spirit of the requirements is met. This section is intended to clarify how the spirit of the requirement is met by the planned capabilities of the instruments.

ID: 4527

As noted in section 1.4.6, both ABI and HES will contribute together to produce products. Typically the HES operated more slowly that the ABI and thus it will provide background information that will be updated whenever new HES data is available. The products will use the most recent ABI data as well. Thus, the joint product requirements typically carry the parameters of the ABI (spatial resolution, updates, etc.), considered HES data as the background field rather than imposing the product requirements on the HES as well as on the ABI.

ID: 4528

Cloud Base Height cannot be determined well from GOES. HES will provide feature altitude information the IR signal does not permit retrievals to be performed through clouds, only above clouds. ABI can provide information about cloud horizontal spatial coverage, but does not provide extensive information about vertical coverage. Thus the product will be measured to the extent possible with GOES and with the currently planned instrument parameters. Model outputs will also be employed to generate the product.

ID: 4529

Cloud Layers and Height is limited in the same way as the Cloud Base Height product described in the paragraph above. Thus the product will be measured to the extent possible with GOES and with the currently planned instrument parameters. Model outputs will also be employed to generate the product.

ID: 4532

Volcanic ash can be detected by ABI to meet the refresh rates, but the top height will be supplied by HES, not ABI, which is less frequently than specified.

ID: 4533

Flood Standing Water Detection can be provided by ABI but 5 cm vertical resolution measurements are not possible with ABI; HES data will not necessarily provide 5 cm vertical resolution in deeper standing water.

ID: 4535

ABI will contribute to determinations of the Currents---Offshore: Hemispheric but the measurement accuracy of 0.5 m/sec for some users will not be met.

ID: 4537

The capping inversion Information and the Moisture Flux accuracies are TBS since the government must validate them.

ID: 4538

The visibility: coastal measurement accuracy is TBS since the government must validate it.

ID: 4539

The ocean color measurement accuracy must be revalidated by the government.

ID: 4540

Currently Snow Depth can only be performed by ABI over the plains, where the detection of prairie grass in the snow can serve as an algorithm. Thus the product met by GOES-R is called snow depth over plains.

ID: 4541

The following radiation terms can be determined indirectly through limited spectral measurements from ABI and HES and can be determined to improved accuracy when combined with solar data from other instruments: Downward Solar Insolation: Surface/CONUS, Downward Solar Insolation: Surface/ Hemispheric, Downward Solar Insolation: Surface/ Mesoscale, Reflected Solar Insolation: TOA/ CONUS, Reflected Solar Insolation: TOA/ Hemispheric

The following radiation terms can be determined indirectly through limited spectral measurements from ABI and HES when combined with model outputs or with solar data from other instruments: Downward Longwave Radiation: Surface/ Hemispheric.

ID: 4542

2.11.4 Pre-planned Product Improvement (P^3I)

ID: 4543

The following description of P^3I has been quoted from the GPRD-1fd. "The purpose is to facilitate the early fielding of a GOES-R system, which can fulfill the vast majority of the designated mission requirements and includes a plan to incorporate improvements to the system after initial fielding. P^3I will allow the fielding of GOES-R by the IOC need date and, eventually, significantly more of the capability desired by GOES-R user community. It also reduces program risk and up-front program costs. P3I includes programming resources to accomplish an orderly and cost-effective evolution of a system's capability after fielding. The objectives of P3I are:

ID: 4544

Introduction of higher technological performance during system lifetime through more rapid fielding of technological advances

ID: 4545

Shortening of acquisition and deployment times

ID: 4546

Reduction in system technical, cost and schedule risk

ID: 4547

Extension of system useful life (preventing early obsolescence)

ID: 4548

Reduction of requirements for major system new starts

ID: 4549

Improvement of system operational readiness during the system's lifetime

ID: 4550

This approach will allow the GOES-R Program to develop and produce the basic system while pursuing the technologies required for improvements in parallel with the basic system. This means that funding for the development of the incremental upgrades are part of the original programs funding line and are not handled as a new start."

ID: 6328

Product requirements that have been recordered as P^3I for GOES-R over the global scale will not be met in the GOES-R series timeframe by additional satellites due to their location outside of the planned GOES-R coverage. However the data needs relevant to these requirements will be addressed by international partners as part of an international network of geostationary and other satellites covering these global geographic regions. In addition the GOES-R program will interface will these international partners (TBD). These global products are the nominally the equivalent of the ABI and HES products on the global scale, dominated by the weather products.

ID: 4551

In terms of the constellation, the P^3I improvements may be in terms on additional instrument deployed after the start of the GOES-R series. In terms of the individual instruments, the improvements may be in terms of modularity of the instrument elements that, upon installation to subsequent instrument in the series, would yield improved performance for product enhancement.

ID: 4552

Requirements that fall into this category are listed below, along with a brief reason for the P^3I classification.

ID: 4553

ID: 4554

True color imagery (Full Disk)	Primarily met by other ABI bands, but could be met by P^3I Hyperspectral Imager

ID: 4555

Hail detection: CONUS	Microwave

ID: 4556

Hail Detection: Hemispheric	Microwave

ID: 4557

Hail Detection: Mesoscale	Microwave

ID: 4558

Precipitation Type / Rate: CONUS	Microwave

ID: 4559

Precipitation Type /Rate: Hemispheric	Microwave

ID: 4560

Precipitation Type /Rate: Mesoscale	Microwave

ID: 4561

Atmospheric Vertical Moisture Profile: CONUS, All weather	Microwave

ID: 4562

Atmospheric Vertical Moisture Profile: Hemispheric, All weather	Microwave

ID: 4563

Atmospheric Vertical Moisture Profile: Mesoscale, All weather	Microwave

ID: 4564

Atmospheric Vertical Temperature Profile: CONUS, All weather	Microwave

ID: 4565

Atmospheric Vertical Temperature Profile: Hemispheric, All weather	Microwave

ID: 4566

Atmospheric Vertical Temperature Profile: Mesoscale, All weather	Microwave

ID: 4567

Capping Inversion: CONUS, All weather | Microwave

ID: 4568

Capping Inversion: Mesoscale, All weather | Microwave

ID: 4569

Moisture Flux: CONUS, All weather | Microwave

ID: 4570

Moisture Hemispheric: CONUS, All weather | Microwave

ID: 4571

Moisture Flux: Mesoscale, All weather | Microwave

ID: 4572

Total Water Content: CONUS, All weather | Microwave

ID: 4573

Total Water Content: Hemispheric, All weather | Microwave

ID: 4574

Total Water Content: Mesoscale, All weather | Microwave

ID: 4575

Tropical Cyclone Inner Core Temperature: Mesoscale | Microwave

ID: 5848

Radiances: CONUS: Microwave (all weather) | Microwave

ID: 5849

Radiances: Hemispheric: Microwave (all weather) | Microwave

ID: 5850

Radiances: Mesoscale: Microwave (all weather) | Microwave

ID: 5852

Snow Depth: CONUS | Microwave

ID: 4577

Snow Depth: Hemispheric — Microwave

ID: 4578

Snow Depth: Mesoscale — Microwave

ID: 4579

Snow Water Equivalent: CONUS — Microwave

ID: 4580

Snow Water Equivalent: Hemispheric — Microwave

ID: 5853

Soil Moisture: CONUS — Microwave

ID: 4582

Soil Moisture: Hemispheric — Microwave

ID: 5854

Surface Type: Hemispheric — P^3I Hyperspectral Imager and another far IR instrument and Microwave

ID: 5855

Ice of Land Origin (Icebergs and Ice Shelves): Hemispheric — P^3I Hyperspectral Imager

ID: 5856

Ocean Wave Characteristics: Significant Wave Height, Direction, Period: CONUS — Microwave (low res)

ID: 5857

Ocean Wave Characteristics: Significant Wave Height, Direction, Period: Hemispheric — Microwave (low res)

ID: 6357

Sea and Lake Ice: Edge: Hemispheric — P3I Hyperspectral Imager

ID: 5858

Sea Surface Temperature: Coastal — Possibly P^3I Hyperspectal Imager

ID: 5859

Sea Surface Temperature: CONUS	Possibly P^3I Hyperspectal Imager

ID: 5860

Sea Surface Temperature: Hemispheric	Possibly P^3I Hyperspectal Imager

ID: 5861

Sea and Lake Surface Winds: CONUS	Microwave

ID: 5862

Sea and Lake Surface Winds: Hemispheric	Microwave

ID: 4583

Sea Surface Winds: Coastal	Microwave

ID: 4584

Sea Surface Winds: Coastal/Offshore	Microwave

ID: 4585

Sea Surface Winds: Hemispheric	Microwave

ID: 4586

Sea Surface Winds: Mesoscale	Microwave

ID: 4588

Total Electron Content (TEC)	Requires Incoherent Scatter active Radar (interference problems) or in situ sensor

ID: 4589

Auroral Boundary	Separate UV sensor or part of Hyperspectral Imager

ID: 4590

Airglow Emissions and Airglow	P^3I Hyperspectral Instrument

ID: 4592

Auroral Energy Deposition	Separate UV sensor or part of Hyperspectral Imager

ID: 4593

Auroral Imagery	Separate UV sensor or part of P^3I Hyperspectral Imager

ID: 4594

Electron Density Profiles	Requires Active Radar (interference problems) or in situ sensor

ID: 4595

Ionospheric Scintillation	Requires Incoherent Scatter active Radar (interference problems) or in situ sensor

ID: 4596

Neutral Density Profile	Requires Incoherent Scatter active Radar (interference problems) or in situ sensor

ID: 4597

Optical Backgrounds	P^3I Hyperspectral Instrument

ID: 4600

Upper Atmospheric Neutral Winds	Low quality at best with P^3I Hyperspectral Imager; high quality winds requires separate complex instrument

ID: 5847

Downward Solar Insolation: TOA/CONUS	Solar Irradiance Monitor

ID: 4601

Solar Flux: Spectral Irradiance	Solar Irradiance Instrument

ID: 4602

Solar Flux: Total Irradiance	Solar Irradiance Instrument

ID: 4603

Solar Radiation Imagery: Corona Images	Solar Coronagraph

ID: 4604

Solar Radiation Imagery: EUV Images	Other new instrument, may be part of more complex Solar Coronagraph

ID: 4605

Solar Radiation Imagery: Far IR and Optical Images	Other new instrument; may be part of more complex Solar Coronagraph

ID: 4606

Solar Radiation Imagery: Magnetoheliograph	Other new instrument or expanded magnetometer capabilities

ID: 4607

Solar Radiation Imagery: Solar Radio (Total Flux and Burst Location)	Other new instrument or part of very expanded Solar Irradiance Instrument

ID: 4608

Absorbed Shortwave Radiation: Surface/ Hemispheric	Proxy from ABI and Solar Irrad. Monitor

ID: 4609

Absorbed Shortwave Radiation: Surface/ Mesoscale	Proxy from ABI and Solar Irrad. Monitor

ID: 4612

CH_4 Concentration	HES, but requires extensive integration time time and competes with other tasks

ID: 5851

CO_2 Concentration	Other new instrument or HES but requires extensive integration and competes with other tasks

ID: 4613

ID: 4614

2.11.5 Interface to Other Segments

ID: 4615

Interface to Ground-located Command, Control, and Communications Segment

ID: 4616

Interface to Product Generation and Distribution Segment

ID: 4617

3. GROUND-LOCATED COMMUNICATION, COMMAND, AND CONTROL (GL-C^3) SEGMENT

ID: 4618

This segment is described in Section 3.3.

ID: 4619

The definitions from this segment are provided here to clarify requirements using the defined terms.

ID: 4620

An **anomaly** is a deviation or departure from the normal. It doesn't necessarily require an action, but it needs to be explained and or investigated.

ID: 4621

A **contingency** is either a description of an activity, or a type of procedure or other documentation written to correct, and/or prevent, and/or mitigate a potential problem or an anomaly.

ID: 6318

Raw Data: Data in their original packets, as received from a satellite.

ID: 6319

Level 0: Reconstructed unprocessed instrument data at full space-time resolution with all available supplemental information to be used in subsequent processing (e.g. ephemeris, health and safety) appended.

ID: 6320

Level 1a: Unpacked, reformatted and resampled level 0 data, with all supplemental information to be used in subsequent processing appended. Data generally presented as full space/time resolution. A wide variety of sub-level products are possible.

ID: 4622

Level 1b data: Unpacked, reformatted, and resampled level-0 data, with all supplemental information to be used in subsequent processing appended. Radiometric and geometric correction applied to produce parameters in physical units. Data generally presented as full space/time resolution. (This is identical to the earth-referenced instrument data with radiometric calibration applied and all calibration data appended).

ID: 6321

Level 2: Retrieved environmental variables (e.g. sea surface temperature) at the same resolution and location as the level 1 source.

ID: 6322

Level 3: Data or retrieved environmental variables which have been spatially and/or temporally resampled (i.e. derived from level 1 or 2). Such resampling may include and averaging and compositing.

ID: 6323

Level 4: Model output or results from analyses of lower level data (i.e. variable that is not directly measured by the instruments, but is derived from these measurements.

ID: 4623

Real time is the designation applied to the propagation of data through a system with minimum time delays. Examples of minimum time delays include any of the following: speed of light propagation; buffering due to compressing, packetizing, framing, and coding; and channel sharing such as required for the CCSDS CVCDU protocols.

ID: 6340

Mean Time to Failure is the expected time that a system/component will operate before the first failure will occur.

ID: 6341

Mean Time to Repair is the average time required to repair a system/component

ID: 4624

Absolute Time Sequence is defined as a sequence of numbered commands programmed such that each command executes at a specific time.

ID: 4625

Relative Time Sequence is a sequence of numbered commands programmed such that each command executes at a time relative to the execution time of the previous command in the sequence.

ID: 4626

3.1 IMPLICATIONS OF MISSION REQUIREMENTS CROSSING ALL SEGMENTS

ID: 4627

3.1.1 Mission security in this segment

ID: 4628

Security shall be maintained in the GL-C^3 Segment communications so that there is no interference with the required transmissions and receptions. Security measures shall be incorporated in the GL-C^3 Segment to both prevent unauthorized access to telemetry streams and provide positive isolation of control functions to reduce risks associated with controlling multiple spacecraft and payloads.

ID: 4629

3.1.2 End to end validation in this segment

ID: 4630

The GL-C^3 Segment shall provide end-to-end validation of data transfers between all GL-C^3 Segment interfaces.

ID: 4631

3.1.3 Configuration Management and Documentation

ID: 4632

3.1.3.1 Configuration Management

ID: 4633

The GL-C^3 Segment shall maintain configuration control of hardware, software, documentation, and databases.

ID: 4634

The GL-C^3 Segment shall use a Configuration Management Plan, subject to Government approval, tailored to the Life Cycle processes associated with the GL-C^3 Segment.

ID: 4635

The GL-C^3 Segment Configuration Management Plan shall include, but not be limited to, the following activities: Configuration Identification, Configuration Control, Configuration Status Accounting, Configuration Evaluation, Release Management and Delivery, and other items that are TBD.

ID: 4636

3.1.3.2 Documentation

ID: 4637

All GL-C^3 Segment hardware and software shall be described in appropriate engineering documentation.

ID: 4638

All GL-C^3 Segment engineering documentation shall be delivered to configuration management, controlled by CM and maintained.

ID: 4639

All documentation shall be prepared according to documentation standard subject to government approval.

ID: 4640

Discussion: The documentation will be developed to a level to support operations, sustainment, upgrade, modification, and re-procurement of all hardware and software. This documentation includes both COTS and custom software.

ID: 4641

Operations and Maintenance (O & M) manuals for all hardware and software provided with the GL-C^3 Segment shall be provided in electronic form.

ID: 4642

At a minimum, this includes configuration, installation, and interconnect diagrams.

ID: 4643

O & M manuals for all operations within the GL-C^3 Segment shall be provided in electronic form.

ID: 4644

This includes at a minimum functional operations description. The GL-C^3 Segment should use vendor-supplied ICD for each electrical and data transfer media interface with the GL-C^3 Segment, including links to domestic, civilian, or military communications networks, and existing facilities at the SOCC, CDAs, processing centers and Direct Receive Sites.

ID: 4645

3.1.3.3. GL-C3 Training

ID: 4646

GL-C^3 training shall be done in accordance with section 6.3.5

ID: 4647

3.1.4 System Availability

ID: 4648

The GL-C^3 Segment shall have no single point failures.

ID: 4649

The Operational Availability for the GL-C^3 Segment shall be at TBD, where the Operational Availability incorporates hardware elements, hardware functions, and software functions.

ID: 4650

Discussion: This includes downtime for maintenance.

ID: 4651

The GL-C^3 Segment shall have an availability of 0.9999 (***TBR***) for Satellite Operations on a monthly basis.

ID: 4652

Discussion: This includes downtime for planned maintenance and other functions.

ID: 4653

The Availability should be substantiated with at least:

1) Measures of Mean Time Between Failure (MTBF) and Mean Time to Repair (MTTR) for all components
2) Reliability analyses addressing redundancies.

ID: 4656

3.2 IMPLICATIONS OF MISSION REQUIREMENTS CROSSING MULTIPLE SEGMENTS

ID: 4657

3.2.1 Data latency in this segment

ID: 4658

Data latency between the measurement of the Sensor Data (SD) by the instrument and the collection of the SD data on the ground shall (TBD) for each instrument unless specified below.

ID: 4659

Data latency between the receipt of data at each GL-C^3 Segment interface and the associated output of data to other GL- C^3 Segment interfaces shall be (***TBD)***.

ID: 4660

For the Advanced Baseline Imager (ABI), calibrated, earth-located, co-registered (band-to-band) image data for CONUS frames shall be ready for dissemination at a NOAA ground station within 1 minute from the time the scanning of the CONUS area is complete. For the mesoscale frames, the latency is 30 second. Similar data from full disk frames must be received by the user portal in their entirety within 6 (TBS) minutes from the scanning end time (THRESHOLD) The GOAL is to improve the data timeliness for the full disk frames.

ID: 4661

For the Hyperspectral Environmental Suite (HES), calibrated, earth-located, co-registered (band-to-band) observed radiance data shall be ready for dissemination in their entirety at a NOAA Ground Station within five (TBS) minutes from the time the measurement of the location is complete (THRESHOLD). The GOAL is to improve the data timeliness to less than 30 (TBS) seconds. Making the radiance data (and derived products) available sooner will increase its value to both forecasters and numerical models.

ID: 4662

3.2.2 Communication Data Standards

ID: 4663

Communication Standards shall be Consultative Committee for Space Data Systems (CCSDS) Recommendations to the extent they can be applied without conflict with other requirements of this document.

ID: 4664

3.2.3 Maintainability

ID: 4665

The GL-C^3 Segment shall allow maintenance to be performed on a non-interference basis with GL-C^3 Segment operations.

ID: 4666

The GL-C^3 Segment shall have an upgrade strategy that allows the insertion of the latest technology and operational capabilities to ensure the most cost effective technical and life cycle advantages during the life of the GOES R program.

ID: 4667

The GL-C^3 Segment shall perform remedial and preventive maintenance for all elements during installation, system checkout and acceptance, Initial Operational Capability (IOC), FOC and extended maintenance periods as defined by NOAA.

ID: 4668

The GL-C^3 Segment shall support facilities and functions implemented to respond to anomalies, faults, and failures.

ID: 4669

The GL-C^3 Segment shall support maintenance of operational interfaces with other applicable GOES R Segments.

ID: 4670

3.3 GENERAL GL-C^3

ID: 4671

The GL-C^3 Segment for the GOES R series of satellites, as foreseen at this time, is described below. This scenario may change as the needs of the system are defined over time. If this is the case, subsequent versions of this document will reflect these changes.

ID: 4672

Figure 5 GL-C^3 Segment Functional Diagram shows the high level functionality of the GOES R GL-C3 Segment. Note that this diagram is intended to be functional only, i.e., system architecture and specific data and operations flow paths are not indicated. Interfaces between functional areas are indicated by a common boundary across which necessary data and operations flows will take place. Other parts of the NOAA infrastructure are shown in the shaded area and the GL-C^3 Segment is shown as a rectangle. As indicated, the GL-C^3 Segment provides the ground-located Space/Ground Communications; performs Satellite Operations; processes Sensor Data (SD); encompasses Life Cycle and Enterprise functions; and interfaces with other Segments and organizations as required.

ID: 4673

The major functions are:

ID: 4674

Space/Ground Communications

ID: 4675

Receiving and forwarding the State of Health (SOH) telemetry downlinks.

ID: 4676

Receiving and forwarding payload data

ID: 4677

Providing the GOES Rebroadcast (GRB - *a subset of Level 1b data*) and Unique Payload Services uplink/downlink

ID: 4678

Providing satellite command uplink for the GOES-R series.

ID: 4679

Servicing the Unique Payload Services

ID: 4680

Satellite Operations

ID: 4681

Generating spacecraft commands and command sequences for uplink

ID: 4682

Determining spacecraft orbit and attitude using star look, range, and landmark data

ID: 4683

Monitoring satellite SOH for the GOES-R series

ID: 4684

Mission planning

ID: 4685

Performing engineering analysis and trending

ID: 4686

Supporting alignment and instrument calibration of satellites in GOES-R series

ID: 4687

ID: 4688

Determine alignment and instrument calibration parameters

ID: 4689

Ge

ID: 4690

Pe

ID: 4691

Ge

ID: 4692

Li

ID: 4693

Co

ID: 4694

Gl

ID: 4695

GL

ID: 4696

Maintenance and Documentation

ID: 4697

ID: 4698

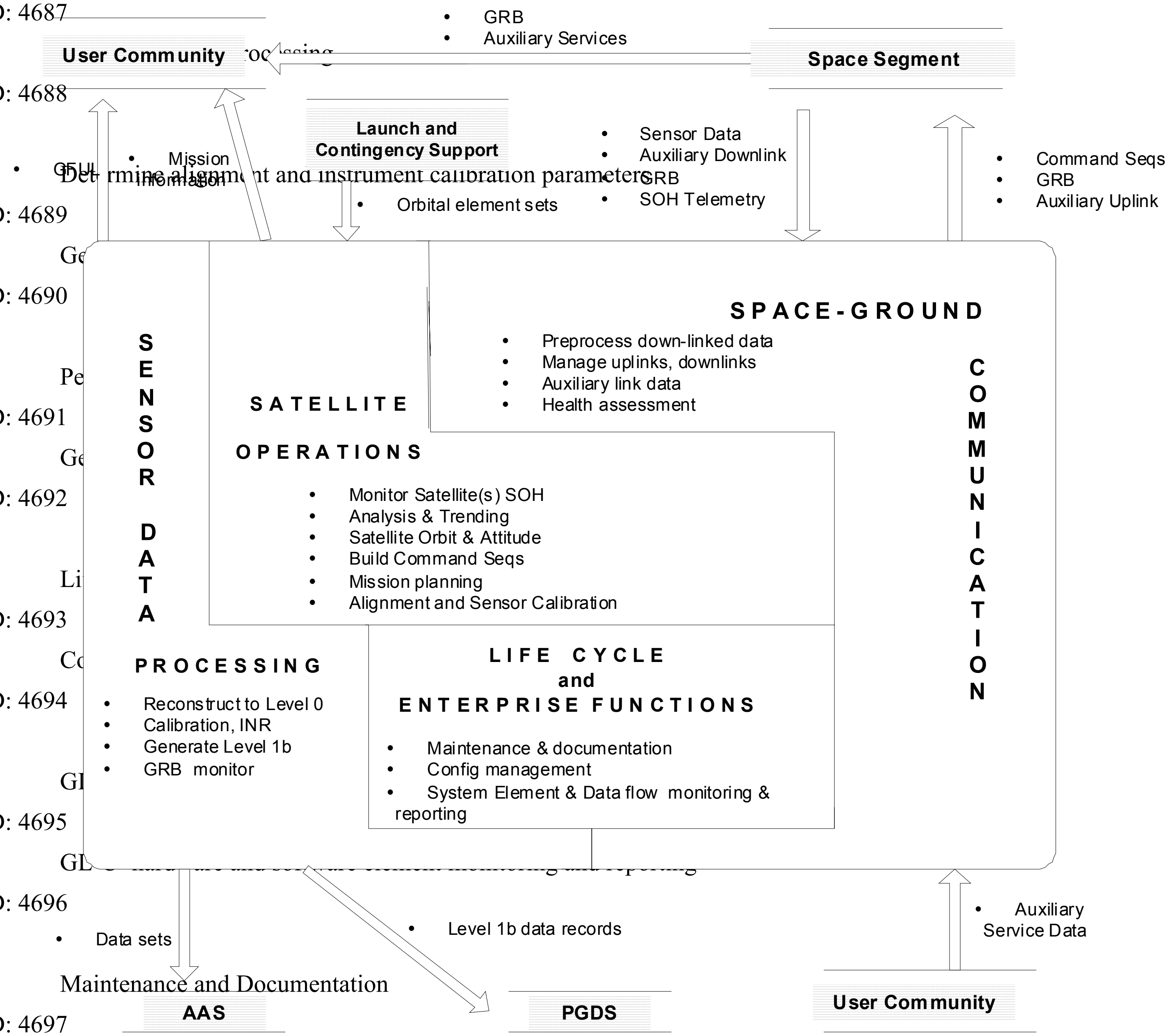

Figure 5. GL-C^3 Segment Functional Diagram

ID: 4699

Note that the Unique Payload Services are the Low Rate Information Transmission (LRIT), Emergency Managers Weather Information Network (EMWIN), Data Collection Platform Interrogation (DCPI), Data Collection Platform Report (DCPR) and Search and Rescue Satellite Aided Tracking (SARSAT). At the time that the GOES R series becomes operational, it is expected the types of Unique Payload Services will be the same as provided by the current system (GOES-N) (indicated as 'continuing service' in this document). It should be noted that some Communication Payload Services may need to provide additional data or functionality, which would require increased transmission rates or added GL-C^3 operations for these services. Where necessary to be compatible with the primary services, frequency changes may be made for any or all of the Communication Payload Services.

ID: 4700

The GL-C^3 will accommodate the increased amount and accuracy of the sensor data associated with the GOES R series Imager and Sounder. Automatic or minimal manual operations are provided for routine daily operations such as schedule generation, scheduler processes, monitoring, and correction of spacecraft anomalies. The uplink rate supports large memory capacity instruments and spacecraft equipment. An integral part of the GOES R GL-C^3 Segment is a System Element and Data Flow functionality that includes monitoring of data flows (command/telemetry and all mission data) within the ground-located system and automatic correction of anomalous network/system hardware and software behavior. Security measures are incorporated in the GL-C^3 Segment that prevent unauthorized access to telemetry streams and provide positive isolation of control functions to reduce risks associated with controlling multiple spacecraft and payloads.

ID: 4701

Currently, the equipment resides at NOAA facilities in the Satellite Operations Control Center (SOCC) in Suitland, Maryland, at the Wallops Command and Data Acquisition Station (CDAS) in Wallops, Virginia (WCDAS), and at the Backup CDAS (BUCDAS) hosted at the Goddard Space Flight Center in Greenbelt, Maryland (for GOES R the Fairbanks CDAS in Fairbanks, Alaska (FCDAS) is considered a backup CDAS). The primary and backup CDASs provide the Radio Frequency (RF) transmit and receive interface with the satellites in the GOES-R series for most functions. Primary GOES command, control, scheduling and engineering operations activities are hosted in the SOCC with complete backup capabilities maintained at the CDASs.

ID: 4702

3.3.1 Operational Lifetime

ID: 4703

The functions and capabilities specified for the GL-C^3 Segment shall be provided for the life of the GOES R series mission(s).

ID: 4704

The GL-C^3 Segment equipment shall be in place and meet all requirements at the primary and backup CDAs and SOCC prior to start of spacecraft Integration and Test (I & T).

Discussion: Spacecraft I&T is likely to be scheduled 2 years prior to launch readiness of GOES-R.

ID: 4705

3.3.2 Satellite Contact

ID: 4706

The GL-C^3 Segment shall have continuous contact with the Satellite constellation.

ID: 4707

3.3.3 Operations Concurrency

ID: 4708

The GL-C^3 Segment shall support configuration control, element and data flow monitoring and reporting, integration, test, and verification activities concurrent with GL-C^3 Segment primary satellites in the GOES-R series and data processing operations.

ID: 4709

3.3.4 Operations Legacy Interface

ID: 4710

The GL-C^3 Segment shall transition seamlessly from legacy to GOES R series operations. This seamless transition shall apply to backup operations, continuity of data flow and processing, and ease of maintenance.

ID: 4711

The GL-C^3 Segment shall overlap operations with GOES R series and legacy satellites as necessary and on a non-interference basis.

ID: 4712

3.3.5 System Capacity

ID: 4713

The GL-C^3 Segment shall ingest, process, and store as a temporal archive, all raw data required to produce the full complement of GOES R series data and products as projected for Final Operational Capability (FOC).

ID: 4714

Discussion: Final Operational Capability for “day-one products” is defined in Section 4.

ID: 4715

The GL-C^3 Segment shall satisfy all Segment functions, including those occurring simultaneously, with no interference or performance degradation of any other Segment functionality.

ID: 4716

3.3.6 Inter-segment Connectivity

ID: 4717

The GL-C^3 Segment shall provide all inter-segment communications between GL-C^3 Segment and the Space-located Segment, between GL-C^3 Segment and Product Generation and Distribution (PGDS), between GL-C^3 Segment and Archive and Access Segment (AAS), and between GL-C^3 Segment and User Segment.

ID: 4718

3.3.7 Element Connectivity

ID: 4719

The GL-C^3 Segment shall provide all connectivity and necessary buffering between elements within the GL-C^3 Segment. The GL-C^3 Segment shall provide all connectivity and necessary buffering between GL-C^3 and PGDS and between GL- C^3 and AAS.

ID: 4720

3.3.8 Routing Performance

ID: 4721

The C^3 Segment shall provide sufficient bandwidth to support the mission.

ID: 4722

3.3.9 Mission Guidance

ID: 4723

The C^3 Segment shall provide mission operations guidance, including mission configuration, maneuver planning, satellite activity prioritization, and data handling.

ID: 4724

The GL-C^3 Segment shall make available mission operational information to the user community.

ID: 4725

3.4 SPACE/GROUND COMMUNICATIONS

ID: 4726

3.4.1 General

ID: 4727

3.4.1.1 Manage Space/Ground Communications

ID: 4728

The GL-C^3 Segment shall manage and provide for space/ground communications during all appropriate test, ground and on-orbit storage, and operational phases for the life of the satellites in the GOES-R series.

ID: 4729

The GL-C^3 Segment shall process data from communication links that are compatible with CCSDS Forward Error Correction (FEC) coding and framing processes to the extent they can be applied without conflict with other requirements of this document.

ID: 4730

3.4.1.2 Simultaneity of Command and Data Acquisitions (CDA) Communications Links

ID: 4731

The GL-C^3 Segment shall concurrently schedule primary and backup ground stations, process telemetry, and monitor the following CDA communications links for the GOES R series:

ID: 4732

a.Command, Command load, and DCPI uplinks

ID: 4733

b.Uplink/downlink for GRB, LRIT, and EMWIN

ID: 4734

c.Real-time telemetry downlinks

ID: 4735

d. Sensor Data downlink

ID: 4736

e. Downlink for DCPR

ID: 4737

3.4.1.3 Communications Status
ID: 4738

The GL-C^3 Segment shall summarize and maintain space/ground communication status and report as necessary.

ID: 4739

Discussion: This pertains to reporting of any breaks in space to ground communication links.

ID: 4740

3.4.2 Assessment

ID: 4741

The GL-C^3 Segment shall maintain an assessment of the space / ground communications functions. Discussion: This pertains to real-time software and hardware.

ID: 4742

3.4.2.1 Antennas
ID: 4743

The GL-C^3 Segment shall perform continuous antenna self checks.

ID: 4744

The GL-C^3 Segment shall monitor and generate reports on antenna health status.

ID: 4745

The GL-C^3 Segment antennas shall automatically track the GOES-R series

ID: 4746

The GL-C^3 Segment antennas shall program track the GOES-R series

ID: 4747

3.4.2.2 Configuration Discrepancy Reporting
ID: 4748

The GL-C^3 Segment shall generate and maintain summary reports of failures and discrepancies (including subsequent resolutions) in space / ground communication functions.

ID: 4749

3.4.3 Telemetry Downlink

ID: 4750

The GL-C^3 Segment shall receive real-time telemetry from the satellites in the GOES-R series formatted according to the CCSDS Recommendation for Telemetry Channel Encoding.

ID: 4751

The GL-C^3 Segment shall monitor and generate status on telemetry downlink functions.

ID: 4752

3.4.4 Sensor Data Downlink

ID: 4753

The GL-C^3 Segment shall receive SD down-linked from the satellites in the GOES-R series according to the applicable CCSDS Recommendations to the extent they can be applied without conflict with other requirements of this document.

ID: 4754

The GL-C^3 Segment shall monitor and generate status on SD downlink functions.

ID: 4755

Discussion: Currently the plan is to send the SIS and SEISS level 0 data to SEC from the GL-C^3.

ID: 4756

3.4.5 Preprocessing of Downlink Data

ID: 4757

The GL-C^3 Segment shall ingest and preprocess received SD to generate level 0 data.

ID: 4758

Discussion: The preprocessing regenerates the level 0 data after the stripping of the CCSDS information.

ID: 4759

3.4.5.1 Real-time Telemetry Preprocessing

ID: 4760

The GL-C^3 Segment shall preprocess received telemetry in real-time according to the applicable CCSDS Recommendations.

ID: 4761

3.4.5.2 Sensor Data Downlink (SD) Preprocessing

ID: 4762

The GL-C^3 Segment shall ingest and preprocess received SD in near real-time according to the applicable CCSDS Recommendations.

ID: 6027

Any delays shall not exceed latencies defined in under the products (first part) of each instrument/payload discussed in Section 2.10.

ID: 4763

3.4.5.3 Virtual Channel Prioritization

ID: 4764

The GL-C^3 Segment shall forward data on the basis of assigned virtual channel identifiers.

ID: 4765

3.4.5.4 Preprocessing Status

ID: 4766

The GL-C^3 Segment shall monitor and generate status on preprocessing functions.

ID: 4767

3.4.5.5 Data Quality Summary

ID: 4768

The GL-C^3 Segment shall generate a real-time data quality summary.

ID: 4769

Discussion: This will include material such as counting the number of frames by source and accounting for the forward error correction process.

ID: 4770

3.4.6 Unique Payload Services

ID: 4771

The C3 Segment shall provide functions as needed to support the Unique Payload Services described in Section 2.8.10.3.2. As described there, these include LRIT, EMWIN, DCPI, DCPR, and Search and Rescue (SARSAT).

ID: 4772

3.4.6.1 LRIT

ID: 4773

The GL-C^3 Segment shall provide an RF interface with the LRIT Unique Payload Services defined in Section 2.10.8.3.2.3.

ID: 4774

The GL-C^3 Segment shall provide LRIT functions as a continuing service.

ID: 4775

The GL-C^3 Segment shall provide for LRIT increased data capacity as necessary.

ID: 4776

3.4.6.2 EMWIN

ID: 4777

The GL-C^3 Segment shall provide an RF interface with the EMWIN Unique Payload Services defined in Section 2.10.8.3.2.4.

ID: 4778

The GL-C^3 Segment shall provide EMWIN functions as a continuing service.

ID: 4779

The GL-C^3 Segment shall provide for EMWIN increased data capacity as necessary.

ID: 4780

3.4.6.3 DCPI

ID: 4781

The GL-C^3 Segment shall provide an RF interface with the DCPI Unique Payload Services defined in Section 2.10.8.3.2.2.

ID: 4782

The GL-C^3 Segment shall provide DCPI functions as defined in Section 2.10.8.3.2.2.

ID: 4783

3.4.6.4 DCPR

ID: 4784

The GL-C^3 Segment shall provide an RF interface with the DCPR Unique Payload Services defined in Section 2.10.8.3.2.2.1.

ID: 4785

The GL-C^3 Segment shall provide DCPR functions as a continuing service.

ID: 4786

The GL-C^3 Segment shall provide for DCPR increased data capacity as necessary.

ID: 4787

Discussion: As discussed in Section 0.2.2, DCS users project a large growth in usage, due to both more platforms and shorter report intervals. Additionally, the NWS estimates the value of DCS to be several billion dollars per year. These factors are likely to drive system loading near the capacity limits of the current DCPR system by the expected GOES R launch date. This will impact not only the Space-Located Segment but also GL-C^3 Segment.

ID: 4788

3.4.6.5 Search and Rescue (SARSAT)

ID: 4789

The GL-C^3 Segment shall provide, as necessary, an RF interface with the SARSAT Unique Payload Services Service defined in Section 2.10.8.3.2.1

ID: 4790

The GL-C^3 Segment shall provide SARSAT functions defined in Section 2.10.8.3.2.1

ID: 4791

The GL-C^3 Segment shall provide SARSAT acknowledgements as necessary.

ID: 4792

3.4.7 Data Flow

ID: 4793

3.4.7.1 Forward Real-time Telemetry

ID: 4794

The GL-C^3 Segment shall forward SOH telemetry and raw sensor data in real-time.

ID: 4795

3.4.7.2 Capture Raw Sensor Data

ID: 4796

The GL-C^3 Segment shall capture and retain raw SD for a minimum of 30 days.

ID: 4797

The GL-C^3 Segment shall provide copies, on request, of the saved SD.

ID: 4798

3.4.7.3 Verify Received Versus Transferred

ID: 4799

The GL-C^3 Segment shall verify data forwarded/transferred against the data received by Product Generation and Distribution Segment and Archive and Access Segment resolve discrepancies.

ID: 6324

A test bed system for end-to-end testing of all components of the GL-C^3 shall be developed and maintained. This test-bed capability shall be maintained after launch to facilitate testing and implementation of new and improved products and services.

ID: 4800

3.5 SATELLITE OPERATIONS

ID: 4801

3.5.1 General

ID: 4802

The GL-C^3 Segment shall provide all uplink(s) of Command and Control data to the GOES R Series including, as a minimum, commands, command loads, software, and spacecraft data.

ID: 4803

3.5.1.1 Calibrations and Alignments

ID: 4804

The GL-C^3 Segment shall support satellite alignment and instrument calibration activities for the GOES-R series.

ID: 4805

3.5.1.2 Satellite Command and Control

ID: 4806

The GL-C^3 Segment shall manage and provide command and control of the satellites in the GOES-R series during all appropriate test and operations phases for the life of the GOES-R series

ID: 4807

3.5.1.3 Removed
ID: 4808

3.5.1.4 Removed
ID: 4809

3.5.2 Mission Planning

ID: 4810

3.5.2.1 Mission Event Planning
ID: 4811

The GL-C^3 Segment shall plan and schedule continuous satellite operations.

ID: 4812

3.5.2.2 Launch Planning
ID: 4813

The GL-C^3 Segment shall plan and support launch and early orbit operations.

ID: 4814

3.5.2.3 Long Range Mission Planning
ID: 4815

The GL-C^3 Segment shall plan and support long-range operations.

ID: 4816

3.5.2.4 Activity Schedule Development
ID: 4817

The GL-C^3 Segment shall generate activity schedule of coordinated Satellite Operations, communications services, and supporting functions for each active satellite.

ID: 4818

The GL-C^3 Segment shall generate activity schedules that span time durations to accommodate on-board capability.

ID: 4819

3.5.2.5 Satellite Maintenance Planning and Scheduling
ID: 4820

The GL-C^3 Segment shall plan and schedule GOES-R series satellite maintenance service activities.

ID: 4821

3.5.2.6 Calibration Planning and Scheduling
ID: 4822

The GL-C^3 Segment shall plan and schedule instrument calibration activities.

ID: 4823

3.5.2.7 Contingency Planning
ID: 4824

The GL-C^3 Segment shall generate pre-planned responses to anomalous conditions for Satellite Operations.

ID: 4825

3.5.2.8 Anomaly Support
ID: 4826

The GL-C^3 Segment shall plan and request support for anomalous operations on an emergency basis.

ID: 4827

3.5.3 Satellite Databases

ID: 4828

3.5.3.1 Satellite Command Database
ID: 4829

The GL-C^3 Segment shall maintain a satellite command database for the life of each satellite.

ID: 4830

3.5.3.2 Satellite Telemetry Database
ID: 4831

The GL-C^3 Segment shall maintain a telemetry database for the life of each satellite.

ID: 4832

3.5.4 Satellite Control and Monitoring

ID: 4833

3.5.4.1 Command Transmission Constraint

ID: 4834

The GL-C^3 Segment shall necessitate operator interaction/confirmation for transmission of commands involving irreversible or degrading actions.

ID: 4835

3.5.4.2 Real-Time Telemetry Processing

ID: 4836

The GL-C^3 Segment shall process telemetry from the GOES-R series in real-time.

ID: 4837

3.5.4.3 Telemetry Format Processing

ID: 4838

The GL-C^3 Segment shall process all spacecraft telemetry formats.

ID: 4839

3.5.4.4 Health and Safety Analysis

ID: 4840

The GL-C^3 Segment shall process and analyze the satellite state-of-health (SOH) telemetry.

ID: 4841

The GL-C^3 Segment shall identify all out-of-limit conditions detected from the processing of all telemetry.

ID: 4842

The GL-C^3 Segment shall configure limit conditions and functions.

ID: 4843

3.5.4.5 Verification of Load Receipt

ID: 4844

The GL-C^3 Segment shall verify that all software, stored command and table loads transmitted to the GOES-R series have been received with no transmission errors.

ID: 4845

3.5.4.6 Verification of Command Execution

ID: 4846

The GL-C^3 Segment shall verify that each command has been correctly executed based on telemetry.

ID: 4847

3.5.4.7 Verification of Load Storage

ID: 4848

The GL-C^3 Segment shall verify that all software, stored command and table loads transmitted to the GOES-R series have been properly stored on board.

ID: 4849

3.5.4.8 Memory Verification

ID: 4850

The GL-C^3 Segment shall command memory dumps from any or all satellite computers in the GOES-R series and perform memory verification.

ID: 4851

3.5.5 Command Preparation

ID: 4852

3.5.5.1 Authentication of and Validation of Commands

ID: 4853

The GL-C^3 Segment shall authenticate all commands.

ID: 4854

The GL-C^3 Segment shall validate all generated command loads.

ID: 4855

3.5.5.2 Command Encryption and Data Deniability

ID: 4856

The GL-C^3 Segment shall encrypt the command link using the method specified in TBS.

ID: 4857

The GL-C^3 Segment shall encrypt on-demand, the real-time direct broadcast of data.

ID: 4858

The GL-C^3 Segment shall maintain operations appropriate to the initiation, duration and cessation of data denial actions.

ID: 4859

3.5.5.3 Command Stream Assembly

ID: 4860

The GL-C^3 Segment shall assemble commands into a command stream according to the CCSDS Recommendation for Telecommand.

ID: 4861

3.5.6 Command Sequence Building

ID: 4862

3.5.6.1 Relative Time Sequence (RTS) Commands

ID: 4863

The GL-C^3 Segment shall generate and use RTS commands in Satellite Operations.

ID: 4864

3.5.6.2 Real-time Commands

ID: 4865

The GL-C^3 Segment shall generate real-time commands.

ID: 4866

3.5.6.3 Absolute Time Sequence (ATS) Commands

ID: 4867

The GL-C^3 Segment shall generate and use ATS commands in Satellite Operations.

ID: 4868

3.5.6.4 Command Load

ID: 4869

The GL-C^3 Segment shall schedule GOES-R series satellite resources.

ID: 4870

The GL-C^3 Segment shall build satellite(s) command loads.

ID: 4871

3.5.6.5 Command Load Updates

ID: 4872

The GL-C^3 Segment shall prepare stored command load updates.

ID: 4873

Discussion: The GL-C^3 Segment needs to be able to build a load for part or all of any table on the spacecraft. This is especially important when working with absolute timed command loads, which may be very large. It is necessary to build replacement commands with associated time and command numbers that are constraint checked with the currently executing load (the copy of that load will be on the ground). The spacecraft will have a corresponding capability to accept and process the partial load.

ID: 4874

3.5.6.6 Command Load Sizing

ID: 4875

The GL-C^3 Segment shall generate stored command loads that span time durations that accommodate on-board capability.

ID: 4876

3.5.6.7 Command Load Processing

ID: 4877

The GL-C^3 Segment shall generate, constraint check, and up-link stored command loads.

ID: 4878

3.5.6.8 Contingency Procedures

ID: 4879

The GL-C^3 Segment shall have predefined contingency procedures for non-nominal mission operations.

ID: 4880

3.5.7 Engineering and Analysis of Satellite Telemetry and Command Data

ID: 4881

3.5.7.1 Trend Analysis

ID: 4882

The GL-C^3 Segment shall generate performance trend analyses using real-time and archived telemetry.

ID: 6028

Discussion: The analyses shall include (but not be limited to) standard statistical tests to determine statistically anomalous events. An example of a statistically anomalous event for a Gaussian distributed telemetry element would be the occurrence of seven increasing or decreasing values in a row. This rule is one of a set of rules known as the Western Electric rules.

ID: 4883

3.5.7.2 Satellite Performance Reports

ID: 4884

The GL-C^3 Segment shall report GOES-R series satellite performance data.

ID: 4885

3.5.7.3 Command and Telemetry Archive

ID: 4886

The GL-C^3 Segment shall archive all telemetry received from, and all commands and loads transmitted to, each satellite for the life of the satellite.

ID: 4887

The GL-C^3 Segment shall archive all logs generated during the processing of telemetry data for the life of the GOES-R series.

ID: 4888

3.5.7.4 Operator Actions and Alarms

ID: 4889

The GL-C^3 Segment shall log all out-of-limit conditions and operator actions.

ID: 4890

3.5.7.5 Archived Data Retrieval and Processing

ID: 4891

The GL-C^3 Segment shall retrieve, process, and trend data archived within the GL-C^3 Segment.

ID: 4892

3.5.7.6 Engineering and Analysis Archive Integrity
ID: 4893

The GL-C^3 Segment shall ensure the engineering and analysis archive shall induce less than 1 bit error in 10^9 bits (***TBR***).

ID: 4894

3.5.7.7 Anomaly Resolution
ID: 4895

The GL-C^3 Segment shall support anomaly investigation and resolution analyses.

ID: 4896

3.5.7.8 Conversion of SOH data to Engineering Units
ID: 4897

The GL-C^3 Segment shall convert all SOH data to engineering units.

ID: 4898

3.5.8 Orbit and Attitude Tracking

ID: 4899

The GL-C^3 Segment shall perform orbit maintenance activities to maintain the orbit for the life of the GOES-R series.

ID: 4900

3.5.8.1 Orbit/Attitude Correction Determination
ID: 4901

The GL-C^3 Segment shall indicate if a correction to the GOES-R series satellite orbit or attitude is required.

ID: 4902

3.5.8.2 Orbit/Attitude Correction Planning
ID: 4903

The GL-C^3 Segment shall plan attitude/orbit correction activities.

ID: 4904

3.5.9 Satellite Simulation

ID: 4905

The GL-C^3 Segment shall provide satellite simulators that generate mode-dependent satellite telemetry in response to command sequences.

ID: 4906

3.5.10 Flight Software Maintenance

ID: 4907

The GL-C^3 Segment shall maintain a current copy of the GOES-R Series satellite onboard software.

ID: 4908

The GL-C^3 Segment shall archive each copy of the GOES-R series satellite on-board software for the life of the GOES-R series.

ID: 4909

3.5.10.1 Spacecraft Flight Software Maintenance

ID: 4910

The GL-C^3 Segment shall maintain the spacecraft flight software.

ID: 4911

3.5.10.2 Spacecraft and Instrument Operations Table Maintenance

ID: 4912

The GL-C^3 Segment shall maintain spacecraft tables.

ID: 4913

The GL-C^3 Segment shall maintain general instrument operations tables.

ID: 4914

3.5.10.3 Instrument Flight Software Maintenance

ID: 4915

The GL-C^3 Segment shall be capable of maintaining the instrument flight software.

ID: 4916

3.5.10.4 Instrument Calibration Table Handling

ID: 4917

The GL-C^3 Segment shall receive and retain a copy of the instrument calibration tables from the associated instrument manufacturers and the PGDS.

ID: 4918

3.5.10.5 Flight Software Verification and Validation

ID: 4919

The GL-C^3 Segment shall validate and verify flight software and tables.

ID: 4920

3.6 SENSOR DATA PROCESSING

ID: 4921

The GL-C^3 Segment shall provide all uplink(s) of operational data to the GOES R Series including, as a minimum, calibration data and instrument parameters.

ID: 4922

Discussion: Data distribution can be accomplished using a different segment if it determined through concept studies and technology and risk trade analyses that this is more efficient.

ID: 6346

Cloud mask data shall be used to produce pointing information for the other instruments, primarily the slower HES.

ID: 6347

Discussion: This may be performed in the PGDS, the GL-C3, or in the spacecraft.

ID: 6348

Discussion: It should also address SDRs used in taking advantage of synergistic relations between different instruments. In a proof-of-concept test for synergistically using information from one instrument to acquire data for another or in this case one satellite platform to better acquire data from another, on February 5, 2004, the Geostationary Operational Environmental Satellite (GOES) Sounder Cloud Top Pressure (CTP) product and National Aeronautics and Space Administration (NASA)'s Science Goal Monitor (SGM) were used to perform a sensor web experiment. Two competing alternate scenes were loaded onboard Earth Observing (EO)-1 (initiated via SGM) and then 4 hours before overflight of the first potential scene, Rapid City, SD, SGM automatically queried the real-time hourly GOES Sounder cloud product to decide whether to proceed with the plan of taking Rapid City, SD or to switch the plan to taking Jornada, NM. As it turns out, Rapid City was very cloudy and Jornada was clear as can be seen from the map generated by GOES and therefore, EO-1 was autonomously commanded to switch targets. There was no manual intervention for this process.

ID: 4923

3.6 1 Generate Level-0 Raw Data Records (RDRs)

ID: 4924

The GL-C^3 Segment shall generate time-referenced, time-ordered, instrument-specific Raw Data Records (RDRs) for each instrument.

ID: 4925

3.6.1.1 Assemble as Instrument Source Packets to form RDRs

ID: 4926

The C^3 Segment shall de-multiplex Coded Virtual Channel Data Unit (CVCDU) data zones to reconstruct RDRs as generated by instruments prior to on-board packetization as described in the Interface Control Document ICD (***TBS***)

ID: 4927

3.6.1.2 Decompress and Route RDRs

ID: 4928

The GL-C^3 Segment shall decompress the RDRs utilizing algorithms appropriate for each instrument.

ID: 4929

3.6.1.3 Conversion of SOH data to Engineering Units

ID: 4930

The GL-C^3 Segment shall convert all instrument SOH data to engineering units.

ID: 4931

3.6.1.4 Assembly of Level-0 RDR Metadata

ID: 4932

The GL-C^3 Segment shall assemble metadata in real-time for RDRs to include at a minimum (***TBD***):

ID: 4933

a. CCSDS header information

ID: 4934

b. Space - Ground ICD information

ID: 4935

c. Received-data quality indicators

ID: 4936

3.6.1.5 RDR Forwarding

ID: 4937

The GL-C^3 segment shall forward RDRs to the appropriate processing stream (TBR).

ID: 4938

3.6.2 Level-1b Sensor Data Records (SDRs)

ID: 4939

The GL-C^3 segment shall generate level 1b data.

ID: 4940

3.6.2.1 Satellite Performance Evaluation

ID: 4941

The GL-C^3 Segment shall evaluate the performance of the GOES-R series with respect to the image radiometry, geometry and temporal registration.

ID: 4942

3.6.2.2 Radiometric Calibration

ID: 4943

The GL-C^3 Segment shall perform radiometric correction of science data using:

ID: 4944

Calibration sources, and

ID: 4945

Calibration parameters generated by the calibration processing provided by the instrument manufacturer.

ID: 4946

The C^3 Segment shall generate calibration parameters.

ID: 4947

The C^3 Segment shall perform radiometric correction of instrument data using algorithms supplied by the instrument manufacturer.

ID: 4948

Discussion: The instruments will measure any calibration sources such as the blackbody, the visible calibrator if present, and space look responses to be used in determining corrective calibration coefficients to apply to the data. Algorithms will be supplied by the instrument vendors to meet specific detector response curves. The calibration coefficients are applied to the instrument data to support image navigation processing.

ID: 4949

3.6.2.3 Geometric Calibration

ID: 4950

The GL-C^3 Segment shall generate state-variables to include, at a minimum, orbit, attitude, gyro bias, and co-registration as used for determining geo-location of instrument samples (TBD).

Discussion: The ground processing determines the anticipated pointing against actual star and landmark measurements. Offsets are determined to support the proper selection and fixation of instrument sample pixels to a threshold ground sample distance. Any oversampling is removed in this process. From this process, the orbit and attitude knowledge based database is constantly updated. The performance of the spacecraft gyro system can be measured from this as well.

ID: 4951

3.6.2.3.1 Generate/Update Application Processing Coefficients

ID: 4952

The GL-C^3 Segment shall generate and/or update application processing parameters based on radiometric and geometric characterization results.

ID: 4953

3.6.2.3.2 Determine need for Instrument Calibration Table updates

ID: 4954

The GL-C^3 Segment shall determine the need for updates to the instrument calibration tables on board the satellite.

ID: 4955

3.6.2.3.3 Record Instrument Updates

ID: 4956

The GL-C^3 Segment shall provide updated instrument calibration tables for subsequent uplink to the GOES-R satellite.

ID: 4957

3.6.2.3.4 Band-to-Band Registration

ID: 4958

The GL-C^3 Segment shall measure and assess band-to-band registration of the imaging and sounding instruments using instrument vendor supplied algorithms.

ID: 4959

Discussion: This is included in the processes that determine the geometric calibration parameter.

ID: 4960

3.6.2.4 Radiometric and Geometric Calibration Summaries

ID: 4961

The GL-C^3 Segment shall archive radiometric and geometric calibration data summarized for each calibration period.

ID: 4962

Discussion: The knowledge data base of radiometric and geometric calibration can be created by sampling the data extractions used in the sample by sample process over some sampling period to build a data base that will be used to measure trends in the performance of the detectors and spacecraft orbit and attitude maintenance.

ID: 4963

The GL-C^3 Segment shall append (TBD) metadata to each sensor data record.

ID: 4964

Discussion: These are appended to each level-1b record to enable users to process the level-1b data independent of other spacecraft data. Typically, these variables include sampling mode, source, temporal, and spectral identifications, relation to sun and moon position, and instrument viewing angle from nadir. The variables also reference external instrument supplied algorithm documentation.

ID: 4965

3.6.3 GOES R Series Level 1b Data

ID: 4966

The GL-C^3 Segment shall make data available (method is TBD) for GFUL.

ID: 4967

GFUL shall consist of ABI, HES, and other instruments Level 1b data. GFUL shall be made available on a continuous basis.

ID: 4968

Discussion: The GOES Level 1b data consists of a set of processed, calibrated and earth-referenced instrument data that is made available to users after processing. GFUL contains the full ABI, HES, and other instruments Level 1b data sets, providing a data rate of more than 100 Mbps.

ID: 4969

ID: 4970

ID: 4971

3.6.3.1 GOES R Series Rebroadcast Data (GRB)

ID: 4972

The GL-C^3 Segment shall have an RF interface for GRB as defined in Section 2.10.8.3.1.

ID: 4973

GRB shall be broadcast to users, in (TBS) format.

ID: 4974

GRB shall occur simultaneously with ingest of data streams from the Space segment.

ID: 4975

GRB shall occur on a continuous basis.

ID: 6029

Discussion: The two types of data that are currently being considered for GOES R are the availability of a full set of this data (GFUL) and a rebroadcast of a subset of this data (GRB). GFUL contains the full ABI, HES, and other instruments Level 1b data sets, providing a data rate of more than 100 Mbps. This data could be sent via ground network or satellite rebroadcast.

Discussion: GRB provides a replacement for the current Goes Variable Format Data (GVAR), as described in section 2.10.8.3.1.

ID: 4976

3.6.4 Product Monitoring

ID: 4977

The GL-C^3 Segment shall provide the capability to display data and images from the GFUL/GRB data.

ID: 4978

The GL-C^3 Segment shall perform radiometric data quality monitoring.

ID: 4979

The GL-C^3 Segment shall perform INR data quality monitoring to include landmark verification.

ID: 4980

The GL-C^3 Segment shall provide predictive orbit and attitude data to the INR function.

ID: 6030

Discussion: The Product Monitoring function(s) are intended to support not only product QA activities but also support troubleshooting of product anomalies occurring in other Ground System Segments. Toward this end, it is expected that the PM function will be replicated in all the Ground System Segments.

ID: 4981

3.6.5 Geo-location Accuracy

ID: 4982

The GL-C^3 Segment shall geo-locate all instrument data in geodetic latitude and longitude. The data shall be corrected for attitude within the accuracy specified for each instrument in this MRD.

ID: 4983

3.6.5.1 Landmark Fit using RDR data

ID: 4984

The GL-C^3 Segment shall use landmark target locations from the earth pointing knowledge database to apply to RDR data to determine actual versus predicted offsets.

ID: 4985

3.6.5.2 Orbit and Attitude Knowledge Data Base

ID: 4986

The GL-C^3 Segment shall update the earth pointing knowledge database in real-time.

ID: 4987

3.7 GL-C^3 SEGMENT SYSTEM ARCHITECTURE

ID: 4988

The GL-C^3 Segment shall autonomously correct anomalies, faults, and failures wherever practicable.

ID: 4989

The GL-C^3 Segment shall use operator-initiated correction of anomalies, faults, and failures wherever practicable.

ID: 4990

The GL-C^3 Segment primary and backup CDA shall have functionally identical RF and computer system architectures and specific programs that are operated and maintained using the same commands and procedures.

ID: 4991

The GL-C^3 Segment SOCC functionality located at primary and backup CDAs shall have functionally identical computer system architectures and specific programs that are operated and maintained using the same commands and procedures.

ID: 4992

GL-C^3 Segment processes shall be modular and scalable to support changing requirements, reduce maintenance, and promote reusability.

ID: 4993

All GL-C^3 Segment user-computer interfaces shall comply with industry accepted ergonomic standards as approved by the Government.

ID: 4994

ID: 6022

3.8 SYSTEM ELEMENT AND DATA FLOW MONITORING AND REPORTING

ID: 6023

The GL-C^3 Segment shall monitor the GL-C^3 Segment performance of hardware components, software components, and system functions to detect anomalies, faults, and failures and extract related information.

ID: 6024

The GL-C^3 Segment shall monitor parameters characterizing data flow within the GL-C^3 Segment to detect anomalies, faults, and failures and extract related information.

ID: 6025

The GL-C^3 Segment shall report, within an interval appropriate to the severity of the anomaly, fault, and/or failure, detected conditions and supporting information to appropriate personnel located throughout the GL-C^3 Segment whenever anomalies, faults, and failures occur or are resolved.

ID: 6026

The GL-C^3 Segment shall generate, at a minimum, summary and statistical trend reports of anomalies, faults, and failures (***TBD***).

ID: 4995

3.9 GL-C^3 SEGMENT INTERFACES

ID: 4996

3.9.1 Space Segment

ID: 4997

The GL-C^3 Segment shall interface with the Space Segment through the GL-C3 Segment communications capability and associated antennas.

ID: 4998

3.9.2 Product Generation and Distribution Segment (PGDS)

ID: 4999

The GL-C^3 Segment shall interface with the PGD Segment via transfer of Level 0 RDRs and Level 1b SDRs to the PGD Segment.

ID: 5000

The GL-C^3 Segment shall interface with the PGD Segment via receipt of mission reports from the PGD.

ID: 5001

3.9.3 Archive and Access Segment (AAS)

ID: 5002

The GL-C^3 Segment shall interface with the AAS through the transmission of data sets.

ID: 5003

The GL-C^3 Segment shall interface with the AAS via receipt of mission reports.

ID: 5004

3.9.4 User Interface Segment

ID: 5005

The GL-C^3 Segment shall transmit GRB data to the user community.

ID: 5006

The GL-C^3 Segment shall distribute Level 1b data to Government processing centers (***TBS***).

ID: 5007

The GL-C^3 Segment shall make Space Environment Monitor (SEM) data and Solar X-Ray Imager (SXI) data available to the Space Environment Center (SEC).

ID: 5008

The GL-C^3 Segment shall make mission status and planning information available to the general user community.

ID: 5009

ID: 5010

3.9.5 Launch and Contingency Support

ID: 5011

The GL-C^3 Segment shall acquire orbital element sets.

ID: 5012

4 PRODUCT GENERATION AND DISTRIBUTION SEGMENT

ID: 5013

4.1 IMPLICATIONS OF MISSION REQUIREMENTS CROSSING ALL SEGMENTS

ID: 5014

4.1.1 Mission security in this segment

ID: 5015

Mission security shall be maintained against unlawful interference or malicious introduction of agents or data.

ID: 5016

4.1.2 End to end validation in this segment

ID: 5017

End to end validation of the product generation and distribution system will be performed.

ID: 5018

4.1.3 Configuration Management and Documentation

ID: 5019

4.1.3.1 Configuration Management

ID: 5020

The Segment shall maintain configuration control of hardware, software, and databases.

ID: 5021

The PGD Segment shall use a Configuration Management Plan, subject to Government Approval.

ID: 5022

4.1.3.2 Documentation

ID: 5023

All Segment hardware and software shall be described in appropriate documentation, including Interface Control Documents (ICDs).

ID: 6031

Discussion: The documentation should be developed to a level to support operations, upgrade, modification, and re-procurement of all hardware and software.

ID: 5024

4.1.4 System Availability

ID: 5025

The Product Generation and Distribution (PGD) Segment shall have no single point failures.

ID: 5026

ID: 5027

The Operational Availability for the PGD Segment shall be at least 99.7% (TBR), where the Operational Availability incorporates hardware elements, hardware functions, and software functions.

ID: 5028

Discussion: This includes downtime for maintenance. Note that 99.7 % is achieved currently and corresponds to outages totaling 4.32 minutes a day.

ID: 5029

The PGD Segment shall have an availability of 0.9999 (***TBR*****),** on a monthly basis, for components associated with the generation of Critical Life and Property products (**TBS)**.

ID: 5030

Discussion: This includes downtime for planned maintenance and other functions. The Availability should be substantiated with at least:

1) published equipment Mean Time Between Failure (MTBF) for all hardware components

2) reliability analyses addressing redundancies.

ID: 5031

ID: 5032

ID: 5033

4.2 IMPLICATIONS OF MISSION REQUIREMENTS CROSSING MULTIPLE SEGMENTS

ID: 5034

4.2.1 Latency in this segment

ID: 5035

The latency between the receipt of the data by the PGDS to the creation of the data products will be near real time (TBR). The latency between the creation of the data products and the distribution of the products to the user portals will be near real time (TBR).

ID: 5036

Discussion: Near real time means as close as possible to real time.

ID: 5037

4.2.2 Maintenance

ID: 5038

The PGD Segment shall allow maintenance to be performed on a non-interference basis with PGD Segment operations.

ID: 5039

The PGD Segment shall have an upgrade strategy that addresses the use of the latest technology and operational capabilities to provide technical and life cycle advantages during the life of the GOES R program.

ID: 5040

The PGD Segment shall perform remedial and preventive maintenance for all elements during installation, system checkout and acceptance, Initial Operational Capability (IOC), Final Operational Capability (FOC) and extended maintenance periods as defined by NOAA.

ID: 5041

Discussion: FOC will be nominally at final acceptance.

ID: 5042

The PGD Segment shall support facilities and functions implemented to respond to anomalies, faults, and failures.

ID: 5043

The PGD Segment shall support maintenance of operational interfaces with other applicable GOES R Segments.

ID: 5044

4.3 GENERAL INFORMATION ON NOAA DATA PROCESSING

ID: 5045

4.3.1 Science Algorithms

ID: 5046

The NOAA-NESDIS Office of Research and Applications (ORA) will be responsible for identifying and/or developing science methodology for the generation of requested products and services as outlined in the GPRD-1fd. The science algorithms will be designed to process level 1b data to generate products from GOES-R instruments, including the ABI, HES, GLM, and any P^3I instruments, if present.

ID: 5047

Science algorithms defined by ORA will be defined in the form of mathematical formulas as well as computer code.

ID: 5048

Required product specifications and characteristics for which science algorithms are developed are listed in section 1.4.6. They are detailed under each instrument under section 2.10 and in the appendix of this document. Any difference between the appendix from the GPRD-1fd and the section 2.10 text is superseded by the text in the latter section.

ID: 5049

Simulated datasets of instrument data will be developed by ORA for use in science algorithm development. This simulated data must accurately represent the full range of environmental conditions (land, ocean, atmosphere, seasonal, etc.) as well as anticipated instrument characteristics. It is recommended that such simulated datasets (along with other tailored reference simulation ancillary data, e.g, "simulated ground truth, models, etc.) be made available to the grounds systems vendor(s). This will allow vendor/(s) to create GRB simulators that will emulate/provide level-1b scenario data for individual and collective instrument data streams under planned operational dissemination modes. It would be most useful to have such simulator(s) system(s) roughly 12-18 months in advance of launch. These datasets should be usable by tests performing *use case* analyses.

ID: 5050

Coordination with customers, including EMC, DoD, etc. for post-launch use of GOES-R+ products will be coordinated through NOAA.

ID: 5051

ORA will determine the lead-time required to meet a 2012 operational readiness date, taking into consideration the schedule for development of the Product Generation and Distribution systems.

ID: 5052

4.3.2 Removed

ID: 5053

4.3.3 Operational Product Processing

ID: 5054

Major components will include communication systems, ground computers, and documentation.

The operational PGDS shall meet all GOES-R product specifications from the GPRD-1fd as detailed in the MRD, including but not limited to product accuracy and coverage.

ID: 5055

A test bed system for end-to-end testing of all components of the PGDS shall be developed and maintained. This test-bed capability shall be maintained after launch to facilitate testing and implementation of new and improved products and services.

ID: 5056

Systems for the distribution of products and services to all customers shall be developed. The distribution methods shall be a function of user requirements and capabilities, specifically relating to centralized versus localized product processing decisions.

ID: 5057

4.3.4 Operational Processing

ID: 5058

The data rates of the GOES-R instruments to the ground are estimated in section 2.10.8.1.2. The decoded and uncompressed data volume is TBS. The PGDS systems shall be sized to produce products from all SD input at two times (TBS) (THRESHOLD) and 10 times (TBS) (GOAL) the data rate received from the GL-C^3 Segment.

Discussion: The minimum estimated uncompressed data rate is estimated to be ~50 Mbps for ABI, ~15 - 60 Mbps for HES, and total ~ 120 Mbps for all instruments. The minimum level 2 products estimate is ~150 Mbps. The maximum product data estimate is 1.5 Gbps.

ID: 5059

Discussion: Currently the plan is to send the SIS and SEISS level 0 data to SEC from the GL-C^3, while meeting the 3-second latency requirement.

ID: 5060

4.4 SYSTEM ELEMENT AND DATA FLOW MONITORING

ID: 5061

The PGD Segment shall monitor and analyze the PGD Segment performance of hardware components, software components, and system functions to detect anomalies, faults, and failures and extract related information.

ID: 5062

The PGD Segment shall monitor and analyze parameters characterizing data flow within the PGD Segment to detect anomalies, faults, and failures and extract related information.

ID: 5063

The PGD Segment shall report, within an interval appropriate to the severity of the anomaly, fault, and/or failure, detected conditions and supporting information to appropriate personnel located throughout the PGD Segment whenever anomalies, faults, and failures occur or are resolved.

ID: 5064

The PGD Segment shall generate, at a minimum, summary and statistical trend reports (TBR) of anomalies, faults, and failures.

ID: 5065

4.5 SYSTEM SEGMENT ARCHITECTURE

ID: 5066

Anomalies, servicing, faults, and failures reporting in the PGD Segment and in the Ground-located Command, Control, and Communications (GL-C^3) Segment shall be integrated.

ID: 5067

The PGD Segment shall manage, develop, test, integrate, and place into operation the hardware and software system components for the maintenance of existing products and the development of new products.

ID: 5068

The PGD Segment shall autonomously correct anomalies, faults, and failures wherever practicable.

ID: 5069

The PGD Segment shall use operator-initiated scripted-correction of anomalies, faults, and failures wherever practicable.

ID: 5070

PGD Segment processes shall be modular and scalable to support changing requirements, reduce maintenance, and promote reusability.

ID: 5071

All PGD Segment user-computer interfaces shall be in accordance with industry accepted ergonomic standards as approved by the Government.

ID: 6035

Discussion: Multiple processing strings operating concurrently may require concurrent ingest of data received from the GL-C^3 Segment or as time-delayed blocks. Some processing strings may require both entire sets of data and data extracted from single or multiple data sets. This could require file management services and buffering internal to the PGD Segment sized to meet both near-real-time and delayed transport of data.

ID: 5072

4.6 PRODUCT GENERATION SYSTEM ELEMENTS

ID: 5073

4.6.1 General

ID: 5074

The PGD Segment shall manage, schedule, and control data processing and resources within the PGD Segment.

ID: 5075

The PGD Segment shall ingest and preprocess received data in accordance with each data format.

ID: 5076

PGD Segment ingest and preprocessing shall include signal processing, decompression and decryption as required, and data routing.

ID: 5077

The PGD Segment shall ingest, process, and store all data required to produce the full complement of GOES R products as projected for FOC.

ID: 5078

The PGD Segment shall generate the full complement of GOES R products as projected for FOC.

ID: 5079

The PGD Segment System Elements shall be expandable to TBS growth in storage and processing capacity over the life of the GOES R Series.

ID: 6036

Discussion: The PGD Segment may experience at least a doubling of products and services during its lifetime. Additionally, processing growth is expected as more sophisticated models and algorithms are developed to leverage the extensive bandwidth and coverage of the GOES R sensors.

ID: 6037

The PGD Segment shall provide the following monitoring and data quality functions:

- display data and images from the GRB data.
- perform radiometric data quality monitoring.
- perform INR data quality monitoring to include landmark verification.
- derive predictive orbit and attitude data.

ID: 6038

Discussion: The monitoring and data quality function(s) are intended to support not only product QA activities but also support troubleshooting of product anomalies occurring in other Ground System Segments. Toward this end, it is expected that these functions will be replicated in all the Ground System Segments.

ID: 5080

4.6.2 Legacy and Concurrent Operations

ID: 5081

The PGD Segment shall support configuration control, element and data flow monitoring and reporting, integration, test, and verification activities concurrent with PGD Segment primary data processing operations.

ID: 5082

The PGD Segment shall operate concurrently with legacy operations with no operational disruption on fulfillment of any requirement.

ID: 5083

Discussion: This transition legacy and concurrent operations will apply to backup operations, continuity of data flow and processing, product distribution, and ease of maintenance. The GOES R Series PGD Segment may be either separate from other NOAA operations supporting POES data processing as it currently does or may be combined with the NPOESS product generation systems to be delivered with the next generation polar satellite programs.

ID: 5084

4.6.3 System Capability

ID: 5085

The PGD Segment shall perform all Segment functions, including those occurring simultaneously, with no interference or performance degradation of any Segment functionality.

ID: 5086

Discussion: The PGD Segment should provide system throughput capacity to support product generation and product distribution functions within data latency requirements. At a minimum, the system should be capable of concurrently supporting two operational satellite configurations with the GOES R sensor payload and projected P^3I suite(s) as well as one additional satellite configuration in test mode. Note that data distribution can be accomplished using a different segment if it is determined through concept studies and technology and risk trade analyses that this is more efficient.

ID: 5087

ID: 5088

The PGD Segment shall provide at least three days (TBR) of untended storage for, at a minimum, the following data:

ID: 5089

a. All received SDRs

ID: 5090

b. Level 2 and any higher level (e.g. level 3) Products

ID: 5091

c. Metadata

ID: 5092

d. Other science data being used in PGDS Processing

ID: 5093

The PGD Segment shall provide bandwidth for all System networks to support the mission within latency requirements.

ID: 5094

The PGD Segment shall provide development, test, and integration capacity to support the Mission and Program requirements on a non-interference basis with product generation and distribution processing.

ID: 5095

Discussion: Three days is the current storage capacity.

ID: 5096

4.7 INTERFACE TO OTHER SEGMENTS

ID: 5097

The PGD Segment shall receive and process data from other observational systems simultaneously.

ID: 5098

The PGD Segment shall receive and process other science data as necessary to generate data products within the PGD Segment.

ID: 5099

Discussion: It is expected that the PGD Segment blended product generation will require processing of data from one or more GEO, LEO, and other satellite(s) instrument(s) sensor(s) as well as other science data (Model data, Forecast data, Grid format data, GRIB format data, Radar data, and Surface Data). The system is expected to accommodate the additional processing load as it becomes necessary during the system lifetime.

ID: 5100

4.7.1 GL-C^3 Segment Interface

ID: 5101

The PGD Segment shall receive Level 1b data and associated metadata from the GL-C^3 Segment.

ID: 5102

The Level 1b data and metadata shall be received as source packets.

ID: 5103

The Level 1b data and metadata shall be received by the PGD Segment ingest processing on the basis of data source, type, and band identifiers.

ID: 5104

The PGD Segment shall provide updated instrument calibration tables to the GL-C^3 Segment.

ID: 5105

The PGD Segment shall generate and transmit reports to the GL-C^3 Segment that contain, as a minimum:

ID: 5106

summary of Level 1b data and metadata received

ID: 5107

summary of link and data quality

ID: 5108

Discussion: All Level 1b data is expected in increments of source packets. Currently, there is no plan for buffering level 1b in the GL-C^3. Any missing scans are reflected in the product. The processing into products takes place in source packets (or many source packets if required to properly re-project or sector the data.)

ID: 5109

4.7.2 Other Satellite Sensor Data Interface(s)

ID: 5110

The PGD Segment shall receive Sensor Data Records (SDRs) formatted as (**TBS**) from Ground Systems for NPOESS, METOP, NASA Satellites, NPP, and other satellites as necessary.

ID: 5111

Discussion: This is intended to address only those Ground Systems providing SDRs used in conjunction with GOES R series data to produce products synergistically.

ID: 5112

These SDRs shall be received by the PGD Segment ingest processing on the basis of data source, type, and band identifiers.

ID: 5113

The PGD Segment shall generate and transmit reports to the GL-C^3 Segment that contain, as a minimum:

ID: 5114

summary of SDR data received

ID: 5115

summary of link and data quality

ID: 5116

Discussion: All SDR data should be appropriately time-stamped.

ID: 5117

4.7.3 Other Science Data Interface(s)

ID: 5118

The PGD Segment shall receive other science data formatted as (**TBS**) from, at a minimum, AWIPS, DAPS, and NCEP centers.

ID: 5119

Other science data shall be received by the PGD Segment ingest processing on the basis of data source, type, and identifiers.

ID: 5120

The PGD Segment shall generate and transmit reports to the GL-C^3 Segment that contain, as a minimum:

ID: 5121

summary of other science data received

ID: 5122

summary of link and data quality

ID: 5123

Discussion: All other science data is expected in increments appropriate to the data type and provided in a documented format with appropriate temporal information.

ID: 5124

4.7.4 Archive and Access Interface

ID: 5125

The PGDS shall transmit all products, associated metadata, and calibration coefficients to the Archive and Access Segment (AAS).

ID: 5126

The PGDS shall provide PGDS software and documentation to the AAS.

ID: 5127

The PGDS shall transmit other science data used in and produced by PGDS processing to the AAS.

ID: 5128

3.2.4 4.7.5 User Interface

ID: 5129

The PGD Segment shall transmit generated products (including Level 1b data) to user portals.

ID: 5130

Discussion: The PGD is expected to provide User distribution for data and products not distributed by the AAS. The user portals currently include AWIPS SBN (via NWSTG), Miami NHC and TPC, Norman SPC, Kansas City AWC, Offutt AFB, Bowie and Camp Springs NCEP, NOAAPORT providers, and the NWSTG.

ID: 5131

The PGD Segment shall receive and log acknowledgments of product receipt from each user.

ID: 5132

The PGD Segment shall provide “push” and “pull” product distribution mechanisms.

ID: 6039

Discussion: Push/pull services are expected to support operational users. These services should possibly offer parsing functionality to minimize data loads for users only requiring portions of complete data sets. This may require data base management services with interactive access to PGD archives.

ID: 5133

The PGD Segment shall provide products formatted as, at a minimum (TBR), GIF, Text, BUFR, GRIB, Binary, JPEG, and McIDAS files or replacement files.

ID: 5134

Discussion: Currently, two classes of products are generated that encompass Level-1b, Level 2, and Level 3: those required to keep up with the GOES space view broadcast (i.e, ingest, process, and dissemination to end user must complete during the space viewing cycle plus whatever time increment before the next GOES view starts), and those that have to complete within some maximum time increment (usually this is a small number of additional minutes) from the receipt of the last dataset needed by the product. The former are termed Instrument Viewing Cycle “IVC” and the latter “Near-IVC”.

ID: 5135

5 ARCHIVE AND ACCESS SEGMENT

ID: 5136

5.1 IMPLICATIONS OF MISSION REQUIREMENTS CROSSING ALL SEGMENTS

ID: 5137

5.1.1 Mission security in this segment

ID: 5138

Mission security shall be maintained to prevent, at a minimum, unauthorized access, interference with inter- and intra-Segment communications, and malicious introduction of agents or data.

ID: 5139

5.1.2 End to end validation in this segment

ID: 5140

The AAS shall perform end-to-end validation of data transfers between all AAS interfaces.

ID: 5141

5.1.3 Configuration Management and Documentation

ID: 5142

5.1.3.1 Configuration Management

ID: 5143

The Archive and Access Segment (AAS) shall maintain configuration control of hardware, software, and databases.

ID: 5144

The AAS shall use a Configuration Management Plan, subject to Government approval.

ID: 5145

5.1.3.2 Documentation

ID: 5146

All AAS hardware and software shall be described in appropriate documentation, including Interface Control Documents (ICDs).

ID: 6040

All documentation shall be prepared in accordance with documentation standards that are subject to US Government approval.

ID: 5147

5.1.4 System Availability

ID: 5148

The Operational Availability for the AAS shall incorporate hardware elements, hardware functions, and software functions.

ID: 6041

Discussion: This includes downtime for maintenance

ID: 5149

The AAS shall have an availability of 0.9999 (***TBR*****),** on a monthly basis, for components associated with the generation of Critical Life and Property products (**TBS)**.

ID: 5150

Discussion: This includes downtime for planned maintenance and other functions. The Availability should be substantiated with at least:

1) Measures of Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR) for all components

2) reliability analyses addressing redundancies.

ID: 5151

ID: 5152

ID: 5153

5.2 IMPLICATIONS OF MISSION REQUIREMENTS CROSSING MULTIPLE SEGMENTS

ID: 5154

5.2.1 Latency in this segment

ID: 5155

The latency between the requests for data to the initiation of the delivery of the data through the on-line system discussed below is TBD.

ID: 5156

The latency between the requests for data to the initiation of the delivery of the data through the bulk delivery discussed below is TBD.

ID: 5157

5.2.2 Maintenance

ID: 5158

The AAS shall perform system maintenance on a non-interference basis with access and distribution operations.

ID: 5159

The AAS shall have an upgrade strategy that addresses the use of the latest technology and operational capabilities to provide technical and life cycle advantages during the life of the GOES R program.

ID: 5160

The AAS shall perform remedial and preventive maintenance for all elements during installation, system checkout and acceptance, Initial Operational Capability (IOC), Final Operational Capability (FOC) and extended maintenance periods as defined by NOAA.

ID: 5161

The AAS shall support facilities and functions implemented to respond to anomalies, faults, and failures.

ID: 5162

The AAS shall support maintenance of operational interfaces with other applicable GOES R Segments.

ID: 5163

5.3 AAS DESCRIPTION

ID: 5164

5.3.1 General

ID: 5165

The AAS Segment, as foreseen at this time, is discussed in this section. This scenario presents current planning and may change as needs are defined and modified over time. If this is the case, subsequent versions of this document will reflect these changes. Note that this section is not intended to levy requirements for the AAS.

ID: 5166

In the GOES R era an upgraded Comprehensive Large Array-data Stewardship System (CLASS), or its follow-on, will be in place to handle the extensive types and volume of environmental data required to be archived and accessed. A more detailed description and a 5-year plan is available for CLASS. *

This system is a re-engineering and upgrade of current archive capabilities serving the National Data Centers (NCDC, NGDC, NODC). Data currently archived includes NWS NEXRAD, ASOS, radiosonde, climatic, and model data; NOS hydrographic data, bathymetric maps, and topographic maps; NMFS (**TBS**), OAR solar radiation, aircraft reports, wind profiler data, and geologic data; NOAA-NESDIS POES and GOES data; and DoD DMSP data. The volume of data in 2000 was 1,000 TB annually. The added requirements for archiving and providing access to NASA EOS, NPOESS NPP, METOP, and full NPOESS data in the 2005 - 2012 timeframe will increase the volume to 13,000 TB annually.

ID: 5167

The CLASS is developed to accommodate significant increases in data while allowing for more efficient and integrated capabilities among the data centers. The CLASS program maintains its own requirements documents in which the GOES R portions will need to be included. While the CLASS GOES ingest function needs to be able to handle the current 2.1 Mb/s GOES data rate, the CLASS designers are fully aware of the need for the ingest function to scale up to GOES-R data rates expected to be 150 Mb/s or more by 2012.

ID: 5168

5.3.2 Ingest and Archive Considerations

ID: 5169

The current plan is that CLASS will be a single software system operating at two distinct locations, one in the Washington, DC metropolitan area (currently Suitland, MD) and the other in Asheville, NC. Datasets will be ingested and archived in robotic storage (see the previous paragraph for storage estimates) at one location and immediately mirrored in robotic storage at the other location via telecommunications links. Each site will have failover capability (i.e., in the event of failure at one site, the other site will automatically take over) to continue ingest and distribution operations. An important component of access capability will be the telecommunications capacity between the CLASS sites (Suitland and Asheville) and the Internet. The NCDC in Asheville is acquiring an OC-3 connection that has a 155 Mbps bandwidth (for comparison a T-1 line has a bandwidth of 1.554 Mbps). Future data rates will require improved capabilities.

ID: 5170

5.3.3 Distribution Considerations

ID: 5171

CLASS will distribute data and products to a wide variety of users ranging from scientists doing weather and environmental research to school children doing homework to other interested parties wanting a satellite image of a recent storm in their area. Users will access the CLASS site via the Internet using a standard web browser. The system will enable Users to search for the data of interest based on source, instrument, time, and location and will provide browse images as a search aid. Future enhancement to

CLASS will potentially enable more advanced search capabilities such as natural language processing, browse animations, and category searches, e.g., “tornados” or “clear days”.

ID: 5172

While most data distribution is expected to be electronic, Users will be able to request media such as CD or tape, although media deliveries will have cost recovery requirements. Electronic delivery will typically be via “pull” FTP, whereby the CLASS system will notify the requester that the requested files are available at a specified FTP site and the user has a specific number of days in which to retrieve the files before they are purged.

ID: 5173

Users can also make arrangements for “push” FTP accounts, whereby the CLASS system will automatically attempt to push the requester’s files to the requester’s system as soon as the files have been retrieved. Furthermore, Users can establish arrangements for subscription service with either “push” or “pull” delivery, which identifies data of interest during data ingest and automatically stages the data for delivery to subscribers. Large orders (having a file sizes or numbers of files beyond certain established parameters) will be handled under “bulk order” processing which will process the requests in the background with a lower priority. Bulk orders can be delivered as multiple partial orders over a period of days, weeks or months, depending on the size of the order, until the full order has been completed. Policies will be established regarding what monetary charges, if any, will apply to specific datasets, specific customers, etc. Some of the factors that drive the bulk order concept are how long does it take to retrieve the files of interest both in 2002 and in the 2012 timeframe, how much processing must be done with the files and how much bandwidth is needed to transmit the delivery order (which may be a subset of the files of interest). Other potential factors establishing priority might be who the customer is (e.g., government customer vs. commercial vs. academic) or whether or not the customer is paying for the data.

ID: 5174

5.3.4 Dataset and Format Considerations

ID: 5175

GOES data to be archived includes Level 1b and derived data products. CLASS will allow users to subset the GOES data, e.g., geographic sub-setting within user-specified spatial, spectral, or temporal limits or a reduced resolution data set using sub-sampling techniques. CLASS will also allow the User to specify alternative data formats, e.g., GVAR (or future GRB), NetCDF or McIDAS area files. Because GOES data products are much smaller in volume relative to the GOES data, they will be archived and distributed in their native formats. However, the system will also provide reference information regarding algorithms used for generating the products, thereby enabling future users to regenerate the products or enhance the algorithms. In cases where GOES data products comprise other data besides GOES data, product regeneration will, of course, be dependent on the availability of the other non-GOES data.

ID: 5176

5.4 SYSTEM ELEMENT AND DATA FLOW MONITORING AND REPORTING

ID: 5177

The AAS shall monitor and analyze the performance of hardware components, software components, and system functions to detect anomalies, faults, and failures and extract related information.

ID: 5178

The AAS shall monitor and analyze parameters characterizing data flow within the AAS to detect anomalies, faults, and failures and extract related information.

ID: 5179

The AAS shall report, within an interval appropriate to the severity of the anomaly, fault, and/or failure, detected conditions and supporting information to appropriate personnel located throughout the AAS whenever anomalies, faults, and failures occur or are resolved.

ID: 5180

The AAS shall generate, at a minimum, summary and statistical trend reports of anomalies, faults, and failures (***TBD***).

ID: 6326

A test bed system for end-to-end testing of all components of the GL-C^3 shall be developed and maintained. This test-bed capability shall be maintained after launch to facilitate testing and implementation of new and improved products and services.

ID: 5181

5.5 SYSTEM SEGMENT ARCHITECTURE

ID: 5182

Anomalies, servicing, faults, and failures reporting in the AAS and in the Ground-located Command, Control, and Communications (GL-C^3) Segment shall be integrated.

ID: 5183

The AAS shall manage, develop, test, integrate, and place into operation the hardware and software system components necessary for the maintenance of existing products and the insertion of new distribution ports.

ID: 5184

The AAS shall autonomously correct anomalies, faults, and failures wherever practicable.

ID: 5185

The AAS shall use operator-initiated scripted-correction of anomalies, faults, and failures wherever practicable.

ID: 5186

AAS processes shall be modular and scalable to support changing requirements, reduce maintenance, and promote reusability.

ID: 5187

All AAS operations user-service computer interfaces shall be in accordance with industry accepted ergonomic standards as approved by the Government.

ID: 5188

5.6 AAS SYSTEM ELEMENTS

ID: 5189

5.6.1 General

ID: 5190

The AAS shall manage, schedule, and control data processing and resources within the AAS.

ID: 5191

The AAS shall ingest and preprocess received data in accordance with each data format.

ID: 5192

The AAS ingest and preprocessing shall include, at a minimum, signal processing, decompression and decryption as required, and data routing.

ID: 5193

The AAS shall ingest, process, and store all data required to produce the full complement of GOES R Series products as projected for FOC.

ID: 5194

The AAS System Elements shall be expandable to permit TBD growth in storage and processing capacity over the life of the GOES R Series.

ID: 6043

The AAS shall provide the following monitoring and data quality functions:

- display data and images from the GRB data.
- perform radiometric data quality monitoring.
- perform INR data quality monitoring to include landmark verification.

derive predictive orbit and attitude data.

ID: 6044

Discussion: The monitoring and data quality function(s) are intended to support not only product QA activities but also support troubleshooting of product anomalies occurring in other Ground System Segments. Toward this end, it is expected that these functions will be replicated in all the Ground System Segments.

ID: 5195

5.6.2 Legacy and Concurrent Operations

ID: 5196

The AAS shall support configuration control, element and data flow monitoring and reporting, integration, test, and verification activities concurrent with AAS primary functional operations.

ID: 5197

The AAS shall include the GOES R Series with no operational disruption on fulfillment of any requirements.

ID: 5198

Discussion: This transition shall apply to backup operations, continuity of data flow and processing, access request processing, data and information distribution, and ease of maintenance.

ID: 5199

5.6.3 System Capability

ID: 5200

The AAS shall fully satisfy all required functions, including those occurring simultaneously, with no interference or performance degradation of any Archive and Access Segment (AAS) functionality.

ID: 5201

The AAS shall provide System processing and throughput capacity to support distribution functions within data latency requirements.

ID: 5202

Discussion: Data distribution can be accomplished using a different segment if it determined through concept studies and technology and risk trade analyses that this is more efficient.

ID: 5203

The AAS shall provide archival storage for, at a minimum, the following data:

ID: 5204

a. All received SDRs

ID: 5205

b. Level 2 and any higher level (i.e. level 3) Products

ID: 5206

c. Metadata

ID: 5207

d. Other science data being used in PGDS Processing

ID: 5208

e. Other information

ID: 5209

The AAS shall provide bandwidth for all System Segment networks.

ID: 5210

The AAS shall provide processing capacity in the System Elements to support the mission within latency requirements.

ID: 5211

The AAS shall provide development, test, and integration capacity to support the Mission and Program requirements on a non-interference basis with product generation and distribution processing.

ID: 5212

5.7 INTERFACE TO OTHER SEGMENTS

ID: 5213

5.7.1 Interface to Other Segments

ID: 5214

The AAS shall receive and process data, requests, and distribution from (**TBS)** ports simultaneously.

ID: 5215

The AAS shall receive and process requests based on User and data subscription properties including, at a minimum, priority, viewing privileges, and data release constraints.

ID: 5216

The AAS shall authenticate all data requests and deny data requests from designated Users when directed by appropriate authority.

ID: 5217

The AAS shall maintain operations appropriate to the initiation, duration, and cessation of data denial actions.

ID: 5218

5.7.2 GL-C3 Segment Interface(s)

ID: 5219

The AAS shall receive Level 1b data and associated metadata from the GL-C^3 Segment.

ID: 5220

The Level 1b data and metadata shall be received in real-time in source packets.

ID: 5221

The AAS shall archive Level 1b data and metadata and make them available for retrieval within (**TBD**) time frame.

ID: 5222

The AAS shall generate and transmit reports to the GL-C^3 Segment that contain, as a minimum:

ID: 5223

summary of Level 1b data and metadata received

ID: 5224

summary of link and data quality

ID: 5225

Discussion: All Level 1b data is expected in increments of source packets. Currently, there is no plan for buffering level 1b in the GL-C^3.

ID: 5226

5.7.3 Other Data Interface(s)

ID: 5227

GOES-R archive data shall not interfere with existing archive capabilities.

ID: 5228

5.7.4 Product Generation and Distribution Interfaces(s)

ID: 5229

The AAS shall receive and archive PGDS generated products and make them available for retrieval within (**TBD**) time frame.

ID: 5230

The AAS shall receive and archive PGDS software, documentation, and other science data and make it available for retrieval within (**TBD**) time frame.

ID: 5231

5.7.5 User Interface(s)

ID: 5232

The AAS shall transmit data and information via an appropriate subscription to Users.

ID: 5233

Discussion: The use of the CLASS is being considered for use in distributing PGD products and Level 1b data. It is anticipated that the 'push' subscription service mentioned in the AAS Description will be expanded to include the 'push' of SDRs and products in real-time. This expansion will involve communication links capable of handling the volume of data expected for GOES R Series instrumentation as well as routing of the data to both Users and Data Centers for Archiving. Users include, at a minimum, AWIPS SBN (via NWSTG), Miami NHC and TPC, Norman SPC, Kansas City AWC, Offutt AFB, Bowie and Camp Springs NCEP, NOAAPORT providers, and the NWSTG.

ID: 5234

The AAS shall receive and log acknowledgments of product delivery and receipt to AAS distribution points.

ID: 5235

The AAS shall process and preserve product formats including, at a minimum (TBR), GIF, Text, BUFR, GRIB, Binary, JPEG, and McIDAS files or replacement files.

ID: 6045

Discussion: The AAS could be designed to be a "Point of Presence" for GOES-R satellite data. In this mode, users can acquire data electronically through pull services as soon as data is ingested into the archive system, or users can subscribe to push services from the AAS. The advantage of placing these services in the AAS is to exploit AAS capabilities that provide database management services such as responding to queries and enabling users to parse only the data required to satisfy their needs. The parsing service can operate for both query pull/push services or for standing order subscription services. The GL-C^3 and PGD Segment services can both provide data to the AAS without delay as processed for distribution. The AAS may not service only retrospective users. Enabling the POP mode of operations will expand the availability of GOES-R data to all classes of users using untended electronic data exchange services. Currently NOAA uses the Federal Geophysical Data Committee (FGDC) standards for formatting descriptive metadata to support user queries. NOAA is currently adjusting these services to extend query services to better serve commercial search engines such as "Google" to better focus user queries for data.

There are two classes of users - operational and retrospective. Most operational users requiring real-time data delivery for forecast and warning services will receive their GOES-R data directly from the PGD Segment. There are other near-real-time operational users who may prefer augmented data received from GRB services or choose not to acquire GRB data who could query the GOES-R database to "pull" data in different temporal, spatial, or spectral form depending on a particular needs. The AAS would continue to service retrospective users as is done today.

ID: 5236

6 USER INTERFACE SEGMENT

ID: 5237

6.1 IMPLICATIONS OF MISSION REQUIREMENTS CROSSING ALL SEGMENTS

ID: 5238

6.1.1 Mission security in this segment

ID: 5239

Mission security will be maintained against unlawful interference or malicious introduction of agents or data.

ID: 5240

6.1.2 End to End Validation in this segment

ID: 5241

The UIS will validate the operability of training tools.

ID: 5242

The UIS will revalidate the appropriateness of the training tools on every TBS years.

ID: 5243

The UIS will perform surveys to determine user satisfaction.

ID: 5244

6.1.3 Configuration Management and Documentation

ID: 5245

6.1.3.1 Configuration Management

ID: 5246

The User Interface Segment (UIS) shall maintain configuration control of hardware, software, and databases.

ID: 5247

The UIS shall use a Configuration Management Plan, subject to Government approval.

ID: 5248

6.1.3.2 Documentation

ID: 5249

All UIS hardware and software shall be described in appropriate engineering documentation, including Interface Control Documents (ICDs).

ID: 5250

6.1.4 Reliability

ID: 5251

The Operational Availability for the AAS shall incorporate hardware elements, hardware functions, and software functions.

ID: 5252

The UIS shall have an availability of 0.9999 (***TBR*)**, on a monthly basis, for elements involved software training that are critical to life and property. (TBR)

ID: 5253

Availability shall be substantiated with:

ID: 5254

1) published equipment Mean Time Between Failure (MTBF) for all hardware components

ID: 5255

2) reliability analyses addressing redundancies.

ID: 5256

6.2 IMPLICATIONS OF MISSION REQUIREMENTS CROSSING MULTIPLE SEGMENTS

ID: 5257

None.

ID: 5258

6.3 EDUCATION AND TRAINING

ID: 5259

Space-based remote sensing is going through a major increase in observing capability over the next decade. One major challenge is making sure that managers and users are aware of the latest advances in space-based observing capabilities. The goal is to transfer research results based on atmospheric remote sensing data into NWS operations. There is also the opportunity to expand public outreach.

ID: 5260

6.3.1. Expand Training through VISIT Program

ID: 5261

The GOES Users subcommittee on Training, Education and Outreach proposes that the impending shortfall in providing training and education resources be addressed. This need for education and training can be met by establishing expanded satellite training as part of the Virtual Institute for Satellite Integration Training (VISIT) program. The mission of the VISIT program is to accelerate the transfer of research results based on environmental remote sensing data into NOAA's operations using distance education techniques. NOAA's National Environmental Satellite Data and Information Service and National Weather Service cosponsor the VISIT program. The primary distance training tool used by VISIT is synchronous teletraining.

ID: 5262

6.3.2 Proposal for Satellite (HydroMeteorology) SHyMET Course

ID: 5263

The GOES Users Committee has proposed that the satellite training activities be expanded to provide comprehensive distance learning courses that produce satellite experts in all parts of NOAA's operational programs. The teletraining conducted by the VISIT program (<http://www.cira.colostate.edu/ramm/visit/visithome.asp>) will be one of the training components used for these comprehensive earth observing satellite courses. The training courses will be incorporated into the Department of Defense (DOD) programs and will be included in the World Meteorological Organization's Virtual Laboratory for Education and Training in Satellite Meteorology.

ID: 5264

The goal of the expanded NOAA satellite training program is to develop satellite hydrometeorology experts in support of NOAA and DoD operations.

ID: 5265

The initial activity in fiscal year 2003 is to prepare a detailed proposal for an expanded satellite training course. This enhanced training completes the end-to-end GOES program by ensuring that the users will be prepared for all the new data and products. A major action for fiscal year 2003 is to get initial NOAA approval and funding to begin planning for the Satellite HydroMeteorology (SHyMet) Course

ID: 5266

The new satellite training program will use a blended training format similar to that employed by NOAA's Distance Learning Operations Course (DLOC) for radar. DLOC runs for 8 to 10 weeks of distance training followed by a 4-day residence workshop. DLOC is run once per year in the autumn for 70 to 110 NOAA students. Upon successful completion of DLOC, the students are certified to use the radar data and products as part of NOAA's NWS severe weather warning program.

ID: 5267

The satellite-training course shall be given to 60/100 NOAA students per year. The goal is to have at least one environmental satellite expert in each NOAA operations office.

ID: 5268

A major issue is how to provide the motivation to NOAA's operational staff for taking the time to complete an intensive satellite-training program. The proposal is to provide college credit through NOAA's cooperative institutes as part of the VISIT program.

ID: 5269

The final action is to complete development of new Satellite HydroMeteorology (**SHyMet**) Course as soon as funding and resources are available. Initial course offerings will focus on new data and products available from new satellite instruments available from platforms such as NASA's TERRA and AQUA (with MODIS and AIRS), METOPS (AIRS), NPP, and GIFTS/IOMI.

ID: 5270

6.3.4 Public Outreach Public outreach shall be performed by NOAA.

ID: 5271

Discussion: Public outreach is an important activity because it shows the public the source of the weather data, while generating interest in meteorology, atmospheric research, and space weather research, oceanography, and environmental monitoring. Training courses that are generated for NOAA employees (see section above) could be easily translated to the general public for any of several uses including NOAA web pages, science museum displays, or visitor centers or lobby kiosks. Classroom lessons that could be downloaded from NOAA pages or web pages catering to teachers would clearly be useful for everyday teaching or for special guest teachers and parents.

ID: 5272

6.3.3 Training for satellite operators

ID: 5273

In light of the new systems and the new satellites, training shall be made available by NOAA for all who interact with the new systems and the data from the new systems.

ID: 5274

Discussion: Either videoconference training or in person training will be necessary for current and future satellite operators.

ID: 5275

6.4 INTERFACE TO OTHER SEGMENTS

ID: 5276

Data products from the PGDS and interesting cases from the AAS shall be used in remote teletraining.

ID: 5277

Data products from the PGDS and interesting cases from the AAS shall be used in public outreach.
ID: 5278

ID: 5340

6.4.1 SD Sensor Data

Abbreviations
ID: 5279

AAS Archive and Access Segment
ID: 5280
ABI Advanced Baseline Imager
ID: 5281

ABS Formerly the Advanced Baseline Sounder
ID: 5282
ATS Absolute Time Sequence
ID: 5283

AWC Aviation Weather Center (located in Kansas City)
ID: 5284
AWIPS Advanced Weather Interactive Processing System
ID: 5285

BUCDAS Backup Command and Data Acquisition Station
ID: 5286
CCSDS Consultative Committee for Space Data Systems
ID: 5287

CDA Command and Data Acquisition
ID: 5288
CDAS Command and Data Acquisition Station
ID: 5289

COTS Commercial Off-the-Shelf
ID: 5290
CVCDU Coded Virtual Channel Data Unit
ID: 5291

CW Shelf and Coastal Waters (portion of HES)
ID: 5292
DAPS Data Collection Platform (DCP) Automated Processing System
ID: 5293

DCPI Data Collection Platform Interrogation
ID: 5294
DCPR Data Collection Platform Report
ID: 5295

DS Disk Sounding (portion of HES)
ID: 5296
DOEE Detector Optics Ensquared Energy
ID: 5297

EEZ Exclusive Economic Zone
ID: 5298
EMWIN Emergency Managers Weather Information Network
ID: 5299

FCDASFairbanks Command and Data Acquisition Station
ID: 5300
FEC Forward Error Correction
ID: 5301

FOC Final Operational Capability
ID: 5302
GFUL Complete set of Level 1b data
ID: 5303

GEO Geosynchronous Earth Orbit

ID: 5304

GL-C^3 Ground-located Command, Control, and Communications

ID: 5305

GOES Geosynchronous Operational Environmental Satellite

ID: 5306

GRB GOES Rebroadcast (subset of Level 1b data)

ID: 5307

GVAR Goes Variable Format Data

ID: 5308

HES Hyperspectral Environmental Suite

ID: 5309

I & T Integration and Test

ID: 5310

INR Image Navigation and Registration

ID: 5311

IOC Initial Operational Capability

ID: 5312

IVC Instrument Viewing Cycle

ID: 5313

L Land (portion of HES)

ID: 5314

LEO Low Earth Orbit

ID: 5315

LRIT Low Rate Information Transmission

ID: 5316

LZA Local Zenith Angle

ID: 5317

METOP Meteorological Operational (satellite)

ID: 5318

MRD Mission Requirement Document

ID: 5319

MTBF Mean Time Between Failure (of a system/component)

ID: 6342

MTTF Mean Time to Failure

ID: 6344

MTTR Mean Time to Repair

ID: 5320

NASCOM NASA Communication Network

ID: 5321

NCEP National Center for Environmental Prediction

ID: 5322

Near-IVC Instrument Viewing Cycle plus a small amount of time

ID: 5323

NEdN Noise Equivalent Radiance Error

ID: 5324

NEdT Noise Equivalent Temperature Error

ID: 5325

NHC National Hurricane Center (located in Miami, FL)

ID: 5326

NOAA National Oceanic and Atmospheric Administration

ID: 5327

NWS National Weather Service

ID: 5328

NPOESS National Polar-orbiting Operational Environmental Satellite System

ID: 5329

NPP NPOESS Preparatory Program

ID: 5330

NWSTG National Weather Service Telecommunications Gateway

ID: 5331

O & M Operations and Maintenance

ID: 5332

OO Open Ocean (portion of HES)

ID: 5333

PGD Product Generation and Distribution

ID: 5334

PGDS Product Generation and Distribution Segment

ID: 5335

RDR Raw Data Record

ID: 5336

RF Radio Frequency(ies)

ID: 5337

RTS Relative Time Sequence

ID: 5338

SARSAT Search and Rescue Satellite Aided Tracking

ID: 5339

SBN Satellite Broadcast Network

ID: 5341

SDR Sensor Data Record

ID: 5342

SEC Space Environment Center

ID: 5343

SEM Space Environment Monitor

ID: 5344

SOCC Satellite Operations Control Center

ID: 5345

SOH State of Health

ID: 5346

SPC Storm Prediction Center (located in Norman OK)

ID: 5347

SXI Solar X-Ray Imager

ID: 5348

SSP Satellite Sub-Point

ID: 5349

SW/M Severe Weather / Mesoscale (portion of HES)

ID: 5350

TBD To Be Determined

ID: 5351

TBR To Be Reviewed by the government and the contractor

ID: 5352

TBS To be supplied by the government during the course of the contract.

ID: 5353

TPC Tropical Prediction Center (located in Miami, FL)

ID: 5354

WCDAS Wallops Command and Data Acquisition Station

ID: 5355

7. APPENDIX A: DETAILED REQUIREMENTS FROM THE GPRD-1FD

ID: 5356

The compressed format of the appendix page required that the users in the table below, namely the offices inside NOAA, are listed with abbreviated forms of their names. In this appendix, Threshold is abbreviated with T and Objective (similar to goal) is abbreviated with O. Section 2.11.3 discusses any shortfalls in meeting NOAA's needs as described in the GPRD-1fd. That section also includes a discussion of any variation between the text of the GPRD-1fd requirement and the planned implementation, and the justification.

ID: 5357

(NOTE: The GPRD-1fd is still being reviewed and is subject to change before it is finalized. The tables are still changing and reflect the tables as of Februry 4, 2004. The tables will be posted on the web with the document and will be called Appendix A.)

ID: 5358

8. APPENDIX B: RADIO FREQUENCY ALLOCATION STATUS

ID: 6317

Appendix B will be updated with the details of a new frequency request for the MRD-2B.

ID: 5359

9. APPENDIX C: RADIANCE VALUES FOR THE HES (seperate document due to length)

ID: 5360

The radiance appendix mentioned in Section (2.10.2) 3.B.2.g is a separate document that is very long and thus is provided as a separate document. Coastal, ocean, and land values are still in flux but will be updated to NASA by early August.