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Technical Specifications for the NPOESS Receiver Station (Update)

The USA discussed the development of Direct Broadcast Services for the National Polar-orbiting Operational Environmental Satellite System (NPOESS), including High Rate Data (HRD) and Low Rate Data (LRD) broadcasts. Later this decade, NPOESS spacecraft will begin on-orbit operations and transmit Stored Mission Data to globally distributed ground stations. NPOESS will simultaneously broadcast real-time HRD (X-band) and LRD (L-band) data streams to suitably equipped field terminal systems. The NPOESS LRD service will be closely compatible with, but not identical to, the broadcast parameters for the Advanced High Resolution Picture Transmission (AHRPT) format that have been accepted and approved by the Coordinating Group on Meteorological Satellites (CGMS). The NPOESS prime contractor is developing scalable software for the Interface Data Processing Segment (IDPS) that will run at U.S Centrals and on HRD/LRD field terminals. During the next 3-5 years, the IPO will be working with the DoD/NOAA program offices responsible for field terminals to develop and begin testing prototype terminals for the HRD/LRD broadcasts. Full details on the technical specifications for these HRD and LRD field terminal systems will not be available until mid-2005. The IPO will continue to investigate developments in antenna/receiver technologies and computer systems capable of running scalable IDPS software to identify “lower-cost” solutions for the mobile, lower capability LRD field terminals. The USA will continue to inform and coordinate with CGMS and the World Meteorological Organization (WMO) on the technical specifications for the L-band and X-band direct readout broadcast services on NPOESS.

Technical Specifications for the NPOESS Receiver Station (Update)

1. INTRODUCTION

Over the last nine years, the Integrated Program Office (IPO) has been developing the National Polar-orbiting Operational Environmental Satellite System (NPOESS). Beginning in late 2009, the IPO, through its Acquisition and Operations (A&O) contractor, Northrop Grumman Space Technology (NGST), will launch NPOESS spacecraft into three sun-synchronous orbital planes (1330, 1730, and 2130 Local Solar Time equatorial ascending nodal crossing times) to provide a single, U.S. system capable of satisfying both civil and national security requirements for space-based, remotely sensed environmental data. The advanced technology visible, infrared, and microwave imagers and sounders that are being developed for NPOESS will deliver higher spatial and temporal resolution data to meet user-validated requirements for 55 (including active fires) atmospheric, oceanic, terrestrial, climatic, and solar-geophysical parameters enabling more accurate short-term weather forecasts and severe storm warnings, as well as serving the data continuity requirements for improved global climate change assessment and prediction. Early flight-testing of instruments is planned to reduce development risk and to demonstrate and validate global imaging and sounding instruments, algorithms, and pre-operational ground processing systems prior to delivery of the first NPOESS spacecraft.

To meet U.S. requirements for the 55 geophysical parameters, including specific Department of Defense (DoD) and National Oceanic and Atmospheric Administration (NOAA) user requirements for data latency, the NPOESS Command, Control, and Communications Segment (C^3S) will deliver global Stored Mission Data (SMD) to four U.S. Operational Processing Centers (Centrals) for processing and distribution. Global SMD will be down-linked to 15 globally-distributed, low-cost, unmanned ground stations at Ka-band frequencies (25500-27000 MHz with a carrier frequency of 25.65 GHz, using a bandwidth of 300 MHz and transmitting at a data rate of 150 Mbps) that will be tied to Centrals via commercial fiber-optic networks. This innovative NGST/Raytheon SafetyNet (patent pending) ground system will deliver 75% of the SMD (daily average) to Centrals within 15 minutes and 95% of the data (daily average) within 26 minutes from the time of on-orbit collection. SMD will be the complete, full resolution data set containing all sensor data and auxiliary data necessary to generate all NPOESS Environmental Data Records (EDRs) at the Centrals. Each Central will be equipped with an Interface Data Processor (IDP) consisting of the necessary data ingest and computational hardware/software to process NPOESS Raw Data Records (RDR) into EDRs, using auxiliary and ancillary data as necessary. Processing RDRs into EDRs will require production of intermediate-level satellite instrument Sensor Data Records (SDRs). The SDRs contain the counts and calibration data at geo-located points. RDRs are also provided by the IDP for archive and validation purposes. These data products will be available through the Centrals' IDP as retrievable data records.

NPOESS data, including RDRs, SDRs, EDRs, stored raw mission data, stored and real-time telemetry, and stored data from the ARGOS Data Collection System (A-DCS), will be distributed through the Data Routing and Retrieval (DRR) component of the NPOESS C^3S to the four U.S. Centrals and to the Mission Management Centers. The Centrals' IDP will provide sufficient temporary storage capacity (i.e., storage capacity for multiple passes – minimum of 24 hour storage) to store the RDRs/SDRs/EDRs and ancillary data for immediate use in the Centrals' higher-level product applications. NOAA's National Environmental Satellite, Data, and

Information Service (NESDIS) will maintain the long-term archive of NPOESS data. NESDIS will also be responsible for providing the worldwide user community access to near real-time processed NPOESS data and higher-level products via the NESDIS Central Environmental Satellite Computer System (CEMSCS) servers, as well as access to archived NPOESS data via other distributed servers at the NESDIS Data Centers.

2. DATA TYPES

Three types of NPOESS data will be made available through the four (4) U.S. Centrals:

Raw Data Records (RDRs)

Raw Data Records will be full resolution, unprocessed digital sensor data, time-referenced, with earth (GEO) location (or orbit-located for *in-situ* measurements), radiometric and geometric calibration coefficients appended, but not applied, to the data. Aggregates (sums or weighted averages) of detector samples are considered to be full resolution data if the aggregation is normally performed to meet resolution and other requirements. Sensor data will be unprocessed with the following exceptions: time delay and integration (TDI), detector array non-uniformity correction (i.e., offset and responsivity equalization), and lossless data compression are allowed. All calibration data will be retained and communicated to the ground without lossy compression. For the real-time transmission of raw data to field terminals, lossy compression will be allowed. Additionally, reduced resolution will be allowed in transmission of raw data to Low Rate Data (LRD) field terminals.

Sensor Data Records (SDRs)

Sensor Data Records will be full resolution sensor data that are time referenced, earth (GEO) located (or orbit-located for *in-situ* measurements), and calibrated by applying the auxiliary information, including radiometric and geometric calibration coefficients and geo-referencing parameters, such as platform ephemeris. These data are processed to sensor units (e.g., radar backscatter cross section, brightness temperature, radiance, etc.). Calibration, ephemeris, and any other auxiliary data necessary to convert the sensor units back to sensor raw data (counts) are included.

Environmental Data Records (EDRs)

Environmental Data Records are fully processed sensor data that contain the environmental (geophysical) parameters or imagery that must be generated as user products, as well as any ancillary data required to identify or interpret these parameters or images. EDRs will be generated by the NPOESS IDP at each of the Centrals (or by Interface Data Processing Segment software running on NPOESS compatible High Rate Data (HRD) or LRD field terminals) by applying appropriate algorithms to RDRs/SDRs.

3. DIRECT BROADCAST SERVICES

In addition to the space-to-ground transmission of SMD, NPOESS will simultaneously broadcast two continuous real-time data streams, at High and Low rates, to suitably equipped field terminals worldwide. These direct broadcast/real-time field terminals will be capable of processing

NPOESS RDRs into EDRs by using IDP software appropriate for the type of field terminal. NGST is developing the IDP software that will run on the high-end computer systems at each of the Centrals, as well as the scalable IDP software that will run on the field terminals, including commercial-off-the-shelf systems. The IPO will distribute the non-proprietary IDP field terminal software, software changes, and program updates to field terminal users worldwide.

Data rates for the NPOESS direct readout broadcast services will be much higher than the current Automatic Picture Transmission (APT) or High Resolution Picture Transmission (HRPT) real-time systems on NOAA's Polar-orbiting Operational Environmental Satellites (POES) or the Low Rate Picture Transmission (LRPT) system that will be on the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) Metop spacecraft. NPOESS spacecraft will not have a real-time direct broadcast service in the 137-138 MHz (LRPT) frequency band.

The NPOESS High Rate Data (HRD) broadcast will be a complete, full resolution data set containing all sensor data and auxiliary/ancillary data necessary to generate all NPOESS EDRs (except some Earth Radiation EDRs) and is intended to support users at fixed, regional hubs. The HRD broadcast will be transmitted at X-band frequencies in the 7750-7850 MHz band (carrier frequencies of 7812 MHZ and 7830 MHZ), at a data rate of 20 Mbps, and will require a bandwidth of 30.8 MHz, into a tracking, receive antenna aperture not to exceed 2.0 meters in diameter.

The NPOESS HRD direct broadcast service will be based on the real-time direct broadcast service that will be available on the NPOESS Preparatory Project (NPP) spacecraft that is being developed jointly by the IPO (through NGST) and the National Aeronautics and Space Administration (NASA). After launch in October 2006, NPP will broadcast real-time data at X-band frequencies (in the 7750-7850 MHz band using a carrier frequency of 7812 MHZ at a data rate of 15 Mbps) to users equipped with appropriate field terminals. Technical specifications for the NPP field terminals and format specifications for the RDRs/SDRs for the instruments that will be flown on NPP (Visible/Infrared Imager Radiometer Suite [VIIRS]; Cross-track Infrared Sounder [CrIS]; Advanced Technology Microwave Sounder [ATMS]; Ozone Mapping and Profiler Suite [OMPS]) are not currently available. However, technical information on NPP should be available by mid-2004 and Interface Control Documents for the HRD service on NPOESS should be available by 2005. NASA is developing an NPP Data Exchange Toolkit (NEXT) to support the pre-launch scientific characterization and calibration for the ATMS, CrIS, VIIRS, and OMPS Engineering Development Units (EDUs) and Flight Units. The NEXT will serve as a repository for NPP instrument algorithms (SDRs, EDRs) and support files (ancillary data, etc.). Both the NEXT system and the ground rules for its use are currently under development by NASA and the IPO. Additional information about NEXT is available on the NPOESS Userport developed and hosted by the Cooperative Program for Operational Meteorology, Education & Training (COMET) at: **http://meted.ucar.edu/npoess/**.

The NPOESS IPO and NGST have carefully considered a recommendation from the Coordinating Group on Meteorological Satellites (CGMS) Task Force on Coordination of Data Formats and Frequency Planning for Polar-orbiting Satellites that was convened in January 2001. The Task Force noted that the USA (NOAA) would conform to the CGMS Global Specifications for Advanced High Resolution Picture Transmission (AHRPT) for the NPOESS spacecraft. As a result of this Task Force meeting, the IPO/NGST team has been developing a Low Rate Data (LRD) L-band direct readout broadcast service for NPOESS that will be closely compatible with,

but not identical to, the broadcast parameters for AHRPT. To satisfy U.S. military and civilian user requirements for high resolution and large volume imagery data from the LRD direct broadcast service on NPOESS, certain modifications (described below) to the Global Specifications for AHRPT have been necessary to accommodate the higher data rates from instruments on NPOESS.

The NPOESS LRD L-band broadcast will be transmitted at a carrier frequency of 1706.0 MHz using the full bandwidth of 8.0 MHz at a nominal data rate of 3.88 Mbps, with full Consultative Committee for Space Data Systems (CCSDS) convolutional coding, Viterbi decoding, and Reed Solomon encoding/decoding into a tracking receive antenna aperture not to exceed 1.0 meter diameter. The data rate for the NPOESS LRD broadcast will be about seven times the current data rate for the POES HRPT service and about 10% to15% higher than the 3.5 Mbps data rate for the AHRPT service that will be on EUMETSAT's Metop spacecraft. U.S. military and civilian user requirements for high resolution and large volume imagery data from at least three channels of the Visible/Infrared Imager Radiometer Suite (VIIRS), in addition to data from other NPOESS instruments, have dictated the higher data rate and commensurate 8.0 MHz bandwidth in the 1.7 GHz band for the NPOESS LRD broadcast. Some data compression (Lossy or Lossless) may be employed for the LRD link to accommodate the set of Environmental Data Records (EDRs) that users have specified for this direct broadcast service. As the design for the NPOESS LRD service matures, the data rate may have to be increased above the nominal 3.88 Mbps, even with improved compression techniques, to allow for the full set of LRD data products.

The NPOESS LRD broadcast parameters (frequency, bandwidth, data rate, and data content) were selected to satisfy U.S. requirements for low-rate, real-time direct broadcast, as well as be closely compatible with the CGMS Global Specifications for AHRPT. The principal differences between the CGMS Global Specifications for AHRPT and the NGST technical specifications for the NPOESS LRD service are listed below, following the section headers contained in CGMS Document Number: CGMS 04; Issue: 1.0; Dated: 5 October 1998:

Sec 2.1 Source Packet Structure (Secondary Header)
Epoch (time reference): CGMS - 1/1/2001 NPOESS - 1/1/1958

The NPOESS approach for the first source packet of a segmented message includes within the Secondary Header following, "...Time_of_Day", 8 bits for PSC_Type and 8 bits for Spare.

Sec 4 Data Link Layer

The NPOESS approach has, in place of a 16 bit IN_SDU (Insert Service Data Unit) the following:

32 bits (note: IN_SDU is allowed to be mission Specific)
08 bits Counter_Extension - aids in data accountability
14 bits Spare
10 bits AES_Key_Serial_Number - AES key in use

To keep the coded virtual channel data unit (CVCDU) structure a CCSDS constant length, 16 bits have been removed from the M_PDU_Packet_Zone to reduce the size from 882

octets to 880 octets (in other words... two octets added to IN_SDU and two octets removed from M_PDU_Packet_Zone maintaining a consistent octet count w/CGMS).

Sec 6.1.1 Convolutional Encoding

Code Rate:	CGMS - 3/4	NPOESS - 1/2
Symbol Inversion:	CGMS - no	NPOESS - yes on G2
Puncturing:	CGMS - yes	NPOESS - no
Puncturing Scheme:	CGMS - as defined	NPOESS - n/a

Sec 6.1.2 QPSK Modulation

The NPOESS approach is SQPSK not QPSK.

Sec 6.1.2.2 Modulation Waveform

Roll-off factor Alpha:	CGMS - 0.6	NPOESS - 0.25
Nominal Bandwidth	CGMS - 1698.75 - 1703.25 MHz CGMS - 1704.75 - 1709.25 MHz	
	NPOESS - Carrier RF - 1706.0 MHz Bandwidth - 8.0 MHz	

The NPOESS LRD direct broadcast service will deliver a subset of the full NPOESS sensor data set and is intended for U.S. and worldwide users of field terminals (land and ship-based, fixed and mobile environmental data receivers operated by DoD users and surface receivers operated by other U.S. government agencies, worldwide weather services, and other international users). The NPOESS IDP software for LRD field terminals will allow users of the LRD service to process NPOESS Raw RDRs into EDRs (level 2). The LRD field terminal on-line storage will also provide the capability to store and have available for retrieval, RDRs, SDRs, Temperature Data Records (TDRs), and EDRs (level 0 to level 2) for the last 24 hours relative to the time when the EDR is produced.

The NPOESS LRD service will include data required to satisfy the U.S. user-specified highest priority EDRs for real-time broadcast. The data content of the LRD direct readout broadcast service from the NPOESS spacecraft will be mission specific to satisfy U.S. military and civilian user requirements, but will be comparable to and complement the data content of the L-band direct readout broadcast service that will be used on EUMETSAT's Metop spacecraft. These EDRs are listed in priority order in the following table:

NPOESS LRD DATA PRODUCTS

High Priority EDRs, In Priority Order from Highest to Lowest	
1	Imagery Threshold Attributes: ▪ 0.8 km horizontal spatial resolution (HSR) worst case across scan for at least one visible and one IR band. ▪ Day/night band at night with 2.7 km HSR ▪ Provide Day and Night capability for the Field Terminal User** to: - Interpret High, Mid, and Low Cloud Types - Detect all Fog Types (Valley, Coast, etc.) - Distinguish Between Snow & Clouds - Detect Coastal Water Mass Features (coastal fronts, eddies, river plumes, etc.) - Detect Dust/Aerosol/Haze/Smoke ** The users intend to primarily exploit the LRD Imagery by manual methods (Interpretation, Detection, and Distinction) of inspection of processed images.
2	Atmospheric Vertical Temperature Profile (Surface to 100 mb only) Measurement Accuracy Threshold Attributes: ▪ Surface to 700 mb: 2.5K/1 km ▪ 700 mb to 300 mb: 1.5 K/1 km ▪ 300 mb to 100 mb: 1.5K/3km. Measurement Accuracy attribute applies to clear and cloudy conditions.
3	Atmospheric Vertical Moisture Profile (Surface to100 mb only)
4	Global Sea Surface Winds (Speed and Direction)
5	Cloud Base Height
6	Cloud Cover/Layers
7	Pressure (Surface/Profile)
8	Sea Surface Temperature (SST)

These high priority EDRs will be derived principally from data collected by four primary imaging/sounding instruments flying on the NPOESS spacecraft: the VIIRS; the CrIS paired with the ATMS; and the Conical-scanning Microwave Imager/Sounder (CMIS). The VIIRS and CMIS instruments will be carried as payloads in all three NPOESS orbits. Data from the CrIS/ATMS instruments will be available only from NPOESS spacecraft in the 1330 (A) and 1730 (A) orbits. NOAA plans on using data from the Infrared Atmospheric Sounding Interferometer (IASI) and the Microwave Humidity Sounder (MHS) aboard the EUMETSAT Metop satellite in the 0930(D)/2130(A) orbit to meet U.S. user requirements for temperature and moisture sounding data in this orbit. Data from the Advanced Scatterometer (ASCAT) and the Space Environment Monitor (SEM) on Metop will complement the data that will be available from NPOESS.

Fifteen additional lower priority EDRs will also be included in the NPOESS LRD broadcast. While the eight high priority EDRs will be produced at the LRD "objective" level of performance, including data latency of two minutes for imagery EDR processing and 15 minutes or less for the other EDRs, these lower priority EDRs will be produced between threshold and objective levels with less stringent latency requirements.

	Lower Priority EDRs (no particular order)
	Aerosol Optical Thickness
	Albedo
	Cloud Effective Particle Size
	Cloud Liquid Water
	Cloud Optical Thickness
	Cloud Top Height
	Cloud Top Temperature
	Land Surface Temperature
	Ocean Wave Characteristics – Significant Wave Height
	Precipitation Type/Rate
	Precipitable Water
	Snow Cover/Depth
	Soil Moisture (Surface)
	Suspended Matter
	Total Water Content

4. DEVELOPMENT OF HRD/LRD FIELD TERMINALS

The development of the HRD and LRD field terminals over the next 3-5 years will be a joint effort among the IPO, the DoD/NOAA "agencies" that will use field terminals to receive NPOESS data, and the NPOESS prime contractor, NGST and its team-mate, Raytheon. Under the terms of the Memorandum of Agreement (MOA) between the DOD/NOAA "agencies" and the IPO on the issue of "Field Terminals, Interoperability, and Funding" that was concluded in 2001, the IPO is responsible to:

- Develop, produce and distribute non-proprietary HRD and LRD Interface Data Processing Segment (IDPS) software to the agency field terminal Program Offices for use by identified agency field terminals. The IPO will release IDPS software to commercial vendors for use on civilian commercial-off-the-shelf field terminals.

- Provide the agencies and commercial vendors the HRD/LRD field terminal hardware/software specifications, antenna specifications, and storage requirements necessary to run IDPS data processing software.

- Starting in Fiscal Year 2002 and continuing through about 2005 in a phased development effort, design, build, test, and validate, on representative hardware, HRD and LRD capabilities. These demonstration terminals will be developed using non-proprietary components and comply with Joint Technical Architecture (JTA) standards. The demonstration terminals will be designed to maximize use of existing legacy system antennas (e.g., NOAA High Resolution Picture Transmission (HRPT) terminals, U.S.

Navy SMQ-11/FMQ-17, etc.) with required modifications for radiofrequency (RF) changes. The HRD terminal will be tested using the full real-time downlink from the National Aeronautics and Space Administration (NASA) Earth Observing System (EOS) Terra and Aqua satellites that are currently flying. A full complement of imagery and sounding data will be available. The HRD terminal will also be tested with the NPOESS Preparatory Project (NPP) after its launch in late 2006. NPP will not have a LRD (L-band) real-time broadcast capability. The prototype LRD terminal will be tested on the ground using either NPOESS sensors or other data sources. The IPO will produce and publish the design for the HRD and LRD terminals and any associated design specifications.

- Investigate current and future small antenna technologies that can be used to receive the LRD broadcast. The goal of this effort is to identify antenna options for the small tactical user and commercial LRD users. Proven technologies will be passed to the agencies for their consideration.

- Maintain configuration control of the IDPS software through the Configuration Control Board (CCB) process. Provide IDPS software revisions and NPOESS data format changes that effect field terminals and commercial-off-the-shelf products to the agency field terminal Program Offices as released by the CCB.

- Distribute software changes and program updates to the agency field terminal Program Offices and to commercial vendors for use on civilian commercial-off-the-shelf field terminals.

- Provide decryption software and specifications to only the agencies and vendors designated to receive that capability.

- Manage the decryption key program and develop the distribution strategy to get decryption keys to authorized users through the agency Program Offices.

(Note that to meet U.S. policy requirements for selective data denial, NPOESS will be capable of encrypting selected mission data in all satellite links, excluding the SARSAT and A-DCS real-time downlinks. During selective data denial, authorized users of registered real-time field terminals in the U.S. and international communities will have the capability to automatically decrypt the NPOESS data downlinks using Advance Encryption Standard (AES) decryption equipment in the field terminal systems.)

As part of this MOA, the agencies/users are responsible for procuring, installing, maintaining, and managing the field terminals, both fixed (HRD/LRD) and mobile (LRD), required to satisfy their needs for data from NPOESS. The agencies/users will be responsible for either modifying existing legacy L-band systems (new front-end receivers, processing/display hardware/software exclusive of the NPOESS IDPS that will be provided by the IPO) or procuring new L-band/X-band field terminal systems to receive the NPOESS broadcast(s).

Under the terms of the Acquisition and Operations contract that was awarded to NGST in August 2002, NGST will be responsible for developing, delivering, and supporting the IDPS (hardware and software systems) at each of the four U.S. Centrals, as well as developing, deploying, and supporting the software portion of the NPOESS field terminals. The scope of NGST's field

terminal effort is to develop software for the HRD and LRD field terminals, functionally specify hardware for the field terminal platforms, and define the associated external interfaces.

Conceptually, the HRD/LRD field terminals will consist of a tracking antenna, front-end receiver, and back-end data processing/data display system. More specifically, a complete field terminal system will consist of several subsystems and associated interfaces, depending upon the capabilities of the HRD/LRD field terminals. These subsystems and interfaces are: the NPOESS satellite to Signal Processing Subsystem (tracking antenna [≤ 1m diameter for LRD; ≤ 2m diameter for HRD] and front-end receiver); the Signal Processing Subsystem to Data Application Subsystem (that will host the NPOESS IDPS field terminal software); the Data Application Subsystem to User Display Subsystem; and the Network Communication Subsystem (NCS) to the Data Application Subsystem. The NCS (e.g., Internet connectivity) will provide the necessary linkages to the Centrals for communicating near real-time auxiliary/ancillary data necessary to produce some of the NPOESS EDRs. The NCS will be implemented on the HRD terminals and may be an option on LRD terminals depending upon capabilities and EDR performance levels required by the LRD users. Critical dynamic ancillary data will also be provided with the LRD.

Because NGST is only responsible for delivering the IDPS software that will run on the field terminals, more detailed specifications for the front-end antenna/receiver subsystem or for the back-end processing/display systems have not been fully developed yet. The IPO has concluded a Request For Information (RFI) to solicit industry capabilities and interest in building next generation Meteorological Satellite (METSAT) field terminal and antenna prototypes for NPOESS. Based on the ~6 responses that the IPO received from potential vendors, commercial capabilities currently exist to provide both separate L-band and X-band prototype terminals/antenna systems to receive the NPOESS LRD/HRD data streams, as well as potentially receive all METSAT data from all sources. During the next two years, the IPO will continue to investigate developments in antenna/receiver technologies, including phased-array antenna designs that may provide optimum and potentially "lower-cost" solutions for the mobile, lower capability LRD field terminals. For example, the IPO is currently conducting a "fly-off" competition between two commercial vendors (Cortex and Alcatel) to procure a "low cost" software-programmable X-band receiver. This new receiver will replace the fixed frequency, X-band receiver on the 13-meter antenna at the NOAA Fairbanks, Alaska Command and Data Acquisition Station that is currently being used by the IPO to support the Coriolis/WindSat mission. These new commercially available, software programmable receivers (for L-band and X-band), should be able to easily accommodate the slight differences in transmission characteristics between the CGMS Global Specifications for AHRPT and the NGST technical specifications for the NPOESS LRD direct broadcast service. The IPO will also be working with the DoD/NOAA program offices responsible for field terminals to begin development of prototype NPOESS LRD/HRD hardware/software systems.

The software that is being developed by NGST to run on the HRD/LRD field terminals is scalable from and shares common source code with the IDPS that will run on the high-end computer systems at each of the four Centrals. Based on the expected data rates for the HRD/LRD broadcasts, contact times for satellite passes, and user-specified latency requirements for processed EDRs (2 min for imagery EDRs and 10 min (HRD)/15 min (LRD) for other EDRs), current computer systems with Central Processing Units (CPUs) running at 2.4 GHz, 1 Gigabyte of memory, and storage capacity of 138 Gigabytes will deliver the

necessary performance. This should allow specification of hardware platforms for the field terminal Data Application Subsystem that range from lightweight, 2-CPU systems (equivalent 19.2 GigaFLOPS) for the mobile, low-end LRD terminals to 5-CPU systems (equivalent 48 GigaFLOPS) for the high-end, fixed HRD terminals. If users are willing to increase EDR latency (i.e., accept longer processing times for EDRs) then lower-cost/less capable computers should be able to host the field terminal IDPS software. As computer technology improves and the associated costs decrease, it is expected that multiple commercial-off-the-shelf platforms will be available by 2005-2007 when operational testing of the prototype HRD/LRD terminals begins. During the next 2-3 years, NGST will benchmark the performance of other potentially viable field terminal hardware configurations. Key benefits of sharing common source code between the IDPS and field terminals include simplified training and timely access to the latest algorithms for field terminal users. In particular, for DoD users, the deployed field terminals will be able to provide tactical support based on the same versions of products generated by the IDPS at the DoD Centrals.

5. SUMMARY

Later this decade, NPOESS spacecraft will begin on-orbit operations and transmit Stored Mission Data to globally distributed ground stations for processing/distribution of Environmental Data Records (and higher-level products and applications) at the U.S. Centrals. NPOESS will simultaneously broadcast real-time High Rate Data (X-band) and Low Rate Data (L-band) to suitably equipped field terminal systems. The NPOESS prime contractor for Acquisition and Operations, NGST is developing the software for the Interface Data Processing Segment that will run at the Centrals. Scalable versions of the software are being developed for use on the HRD and LRD systems. During the next 3-5 years, the IPO will be working with the DoD/NOAA program offices responsible for field terminals to develop and begin testing prototype terminals for the HRD/LRD broadcasts. The IPO will continue to investigate developments in antenna/receiver technologies and computer systems capable of running the scalable IDPS software to identify "lower-cost" commercially available solutions for the mobile, lower capability LRD field terminals. Because these terminals will not be required until 2005 (HRD for testing with NPP) and 2007-2008 (LRD for testing with NPOESS) full details on the technical specifications for these field terminal systems, including functional specification of hardware and the associated interfaces will not be available until mid-2005 (for the HRD Interface Control Documents). As the NGST designs for the LRD and HRD services mature, the USA will continue to inform and coordinate with CGMS and the World Meteorological Organization (WMO) on the technical specifications for the L-band and X-band direct readout broadcast services on NPOESS. The IPO, in cooperation with NOAA/NESDIS, is also investigating alternative communications capabilities (i.e., rebroadcast of processed imagery and data via the Internet or "commercial" services) that may allow other-than-direct real-time satellite-to-ground data transmission to follow-on field terminal systems.