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FUTURE POLAR ORBITING METEOROLOGICAL SATELLITE SYSTEMS

The NOAA-WP-07 discussed its future polar-orbiting environmental satellite system. NOAA addressed the current operational system. Information was provided on the international polar-orbiting satellite program coordination between EUMETSAT and NOAA. The goal of this cooperation is to provide continuity of measurements from polar orbits, cost sharing, and improved forecast and monitoring capabilities through the introduction of new technologies. An agreement is in place between NOAA and EUMETSAT on the Initial Joint Polar-orbiting Operational Satellite System (IJPS). This program will include two series of independent, but coordinated NOAA and EUMETSAT satellites, exchange of instruments and global data, cooperation in algorithm development, and plans for real-time direct broadcast.

The NOAA-WP-07 discussed the development and implementation plans for JPSS. Spacecraft will be launched into an orbital plane to provide significantly improved operational capabilities and benefits to satisfy the critical 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 will deliver higher spatial and resolution atmospheric, oceanic, terrestrial, and solar-geophysical data enabling more accurate short-term weather forecasts and significantly improved long range numerical weather forecasts as well as serving the data continuity requirements for improved global climate change assessment and prediction. The program is on the path to creating a high performance, polar-orbiting satellite system that will be more responsive to user requirements and provide sustained, space-based measurements as a cornerstone of an Integrated Global Observing System. These activities represent a sound beginning for achieving the planned national and international operational satellite programs that will ensure continuous support to a variety of users.

FUTURE POLAR ORBITING METEOROLOGICAL SATELLITE SYSTEMS

1. INTRODUCTION

Since 1960, polar-orbiting satellites have collected environmental data from space to support the preparation of informed short-term weather forecasts and warnings. The Polar-orbiting Operational Environmental Satellite (POES) system evolved from the experiences gained in space from ten experimental Television Infrared Observation Satellites (TIROS) and four generations of operational polar-orbiting satellites. Since 1978, the POES system has been operated with a two-satellite constellation in circular, near-polar, sun-synchronous orbits.

The POES program is managed and operated by the National Environmental Satellite, Data, and Information Service (NESDIS) that is part of the National Oceanic and Atmospheric Administration (NOAA). The current POES program will transition to the JPSS program with the launch of NPP planned for October 25, 2011. Operational products from NPP will be phased in between July 2012 and December 2013. Until the new operational satellite systems are available, the current POES and DMSP programs will provide continuous satellite coverage from space to support user needs.

2. CURRENT POLAR MISSION

The primary mission of the POES system is to provide daily global observations of weather patterns and environmental measurements of the Earth's atmosphere, its surface and cloud cover, and the proton and electron flux at satellite altitude; and to establish long-term data sets for climate monitoring and assessment and climate change predictions. Since the beginning of the POES program, environmental data and products acquired by its satellites have been provided to users around the globe.

The POES system comprises on-orbit remote-sensing satellites, and satellite command and control and data processing facilities. NOAA has in place a polar satellite program to replace current satellites as they reach the end of their operational life. This fifth-generation of POES Advanced TIROS-N (ATN) satellites were designated NOAA-K, -L, -M, -N, and –N'. NOAA-K, -L, and -M were upgraded with new primary environmental instruments and were followed by NOAA-N and N' that were updated to a later instrument baseline. The major changes to the environmental instrument baseline for the NOAA-K, -L, and -M satellites, described below, include the AVHRR/3, the HIRS/3, and the AMSU-A and -B.

To support the Polar mission, these satellites carry the following instruments:

<u>Advanced Very High Resolution Radiometer (AVHRR/3):</u> Through modifications to the current AVHRR/2 instrument, a sixth channel has been added for near-IR data. This channel, referred to as 3A, will provide users with the ability to discriminate between clouds and snow and ice. It will be time shared with the previous channel 3, now referred to as 3B. Operationally, channel 3A will be active during the daytime part of each orbit and 3B will be active during the night time part of each orbit.
<u>High Resolution Infrared Radiation Sounder (HIRS/3- HIRS/4):</u> The HIRS is an infrared sounder consisting of one visible, 12 long-wave IR, and 7 shortwave IR channels. The instantaneous field of view (IFOV) and ground sample distance (GSD) for the HIRS/3 (NOAA-17 through -17) are 20 km. The HIRS/4 flying on NOAA-18 (N' and Metop) has a 10 km IFOV with a 20 km GSD. This change was made to increase the number of clear (i.e., cloud free) observations taken by the HIRS instrument.
<u>Advanced Microwave Sounding Unit (AMSU-A and –B or MHS):</u> The AMSU suite is a 20-channel scanning passive microwave radiometer. AMSU-A uses 15 channels to provide data for vertical temperature profiles and additional information on surface water and precipitation to enhance sounding measurements. AMSU-B, provided by the U.K. Meteorology Office (or MHS (Microwave Humidity Sounder) provided by EUMETSAT), is a five-channel microwave radiometer for measuring atmospheric water vapor. AMSU instruments will provide the capability for remote sensing of atmospheric and surface properties on a global basis, as well as improving the detection of precipitation and surface features such as ice and snow cover.
<u>Solar Backscatter-Ultraviolet Spectral Radiometer (SBUV/2):</u> The SBUV provides estimates of the global ozone distribution by measuring back-scattered solar radiation in the ultraviolet Hartley-Huggins bands.
<u>Space Environment Monitor (SEM-2):</u> The SEM is a multi-channel, charged particle spectrometer that measures the population of the Earth's radiation belts and the particle precipitation phenomena resulting from solar activity.
<u>Search and Rescue Satellite Aided Tracking System (SARSAT):</u> The SARSAT receives distress signals from emergency beacons on international distress frequencies and retransmits them to local user terminals for action by appropriate government agencies.
<u>Advanced Data Collection System (A-DCS):</u> The A-DCS (ARGOS) relays meteorological and other data transmitted from in-situ ground-based data collection platforms, including buoys, free floating balloons, and remote weather stations.

NOAA has a user guide for the POES satellites. This information is available on the Internet at the following URL: http://www2.ncdc.noaa.gov/docs/klm/index.htm.

4. International Program Cooperation

In the 1980s, NOAA needed to balance the high cost of space systems and the growing need to provide a complete and accurate description of the atmosphere at regular intervals as input to numerical weather prediction and climate monitoring support systems. This led NOAA to enter into discussions and agreements at the international level with the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). The goal of this cooperation is to provide continuity of measurements from operational satellites in polar orbits, cost sharing, and improved forecast and monitoring capabilities through the introduction of new technologies.

Building upon the POES program, an agreement is in place between NOAA and EUMETSAT on the Initial Joint Polar-orbiting Operational Satellite System (IJPS). This program includes two series of independent, but coordinated NOAA and EUMETSAT satellites, exchange of instruments and global data, cooperation in algorithm development, and plans for real-time direct broadcast. Under terms of the IJPS agreement, NOAA provided NOAA-N and NOAA-N' satellites for flight in the afternoon orbit and EUMETSAT is providing Metop-1 and Metop-2 satellites for flight in the mid-morning orbit. These satellites carry a common core of instruments that includes the AVHRR/3, HIRS/4, AMSU-A, A-DCS, SARSAT, SEM-2, and the Microwave Humidity Sounder (MHS). In addition, NOAA will fly a SBUV/2 instrument on its satellites, while EUMETSAT's additional payloads will include an infrared interferometer sounder, a scatterometer, an ozone instrument, and a Global Positioning System (GPS) occultation sounder.

Under a Joint Transition Activities agreement between NOAA and EUMETSAT, EUMETSAT will provide a third Metop satellite, which like Metop-1 and 2 will carry U.S. instruments (HIRS/4 no longer needed). As a result of discussions between the USA and EUMETSAT, the USA will rely on data from the Infrared Atmospheric Sounding Interferometer (IASI) and MHS on EUMETSAT's Metop satellite in the 0930 orbit to meet the requirements for temperature and moisture sounding data in this orbit.

Coordination on associated ground segments is also included in this agreement, which ensures the sharing of mission data, blind-orbit data capture support, and telecommunications paths through each other's ground stations for back-up command and control functions. The first Metop satellite designated Metop-A, was launched in October 2006.

5 FUTURE POLAR PROGRAM PLANS

5.1 Joint Polar Satellite System (JPSS)

5.1.1 Introduction

Since 1994, the U.S. government was merging the Nation's military and civil operational meteorological satellite programs into a single, integrated, end-to-end satellite system capable of satisfying both civil and national security requirements for space-based remotely sensed environmental data. The joint program formed by a

Presidential Decision Directive was the National Polar-orbiting Operational Environmental Satellite System (NPOESS).

On February 1, 2010 a new Presidential Decision Directive titled **Restructuring the National Polar-orbiting Operational Environmental Satellite System** was issued. This directive required a major restructuring of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) in order to put the program on a more sustainable pathway toward success. The satellite system is a priority essential to meeting both civil and military weather forecasting, storm-tracking, and climate-monitoring requirements. However, the program was behind schedule, over budget, and underperforming. NOAA and the United States Air Force (USAF) will no longer continue to jointly procure the polar-orbiting satellite system called NPOESS. The United States Department of Defense (DOD), NOAA and NASA have and will continue to partner to ensure a successful way forward for the respective programs, while utilizing international partnerships to sustain and enhance weather and climate observations.

NOAA and NASA will take primary responsibility for the afternoon orbit, and DOD will take primary responsibility for the morning orbit. The agencies will continue to partner in those areas that have been successful in the past, such as a shared ground system. NOAA's portion will be named the "Joint Polar Satellite System" (JPSS) and will consist of platforms based on the NPP satellite. The DOD satellite portion will be named the "Defense Weather Satellite System" (DWSS). Partnership with Europe through the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) will continue to be a cornerstone of the polar-orbiting constellation, and will ensure the ability to provide continuous measurements. These changes will better ensure continuity of crucial civil climate and weather data.

While the USAF continues to have Defense Meteorological Satellite Program (DMSP) polar-orbiting satellites available for launch for the next few years, NOAA launched its final polar-orbiting satellite in February 2009. Given that weather forecasters and climate scientists rely on the data from NOAA's current on-orbit assets, efforts will focus on development of the first of the JPSS platforms.

NASA's role in the restructured program will be modeled after the procurement structure of the successful POES and GOES programs, where NASA and NOAA have a long and effective partnership. NOAA and NASA will establish a JPSS program at NASA's Goddard Space Flight Center (GSFC). NOAA and NASA will strive to ensure that current requirements are met on the most practicable schedule without reducing system capabilities.

DOD remains committed to a partnership with NOAA in preserving weather and climate sensing capabilities. For the morning orbit, the current DOD plan for deploying DMSP satellites ensures continued weather observations. DOD will fully support NOAA's needs to ensure continuity of data in the afternoon orbit by transitioning appropriate and relevant activities from the current NPOESS effort.

Significant progress has been made with the NPOESS Preparatory Project (NPP) satellite, now with a launch date of October 25, 2011. All key instruments, the Visible Infrared Imager Radiometer Suite (VIIRS), the Cross-track Infrared Sounder

(CrIS),the Advanced Technology Microwave Sounder (ATMS) , and the Ozone Mapping and Profiler Suite (OMPS), have been tested and shipped from the developers to NPP and integrated onto the spacecraft.. NOAA and NASA have taken advantage of the NPP opportunity to add the Clouds and the Earth's Radiant Energy System (CERES) instrument to NPP. This instrument has been integrated onto the spacecraft and tested for flight, thus ensuring the continuity of this critical data set beyond the NASA EOS (Terra and Aqua) missions.

Partnerships are key to the ability to provide continuous polar-orbiting measurements. NOAA, NASA, and the DOD/Air Force have had a productive relationship in polar observations; sharing data, coordinating user needs, and operating satellites. This cooperative relationship is essential and will continue. Partnerships with Europe through EUMETSAT will continue to be a strong part of the polar-orbiting constellation. Furthermore, a partnership with JAXA will provide products from the GCOM-W1 AMSR-2 microwave imager. Products include sea surface temperature in all weather conditions, total precipitable water, cloud liquid water, rainfall, soil moisture, snow/ice cover, and ocean surface wind speed. These products will replace those from the demanifested NPOESS conical microwave imager sounder (CMIS) sensor in the 13:30 orbit.

Once operational, NPP and JPSS will replace the current POES. The POES spacecraft have revolutionized the way in which we observe and predict the weather. We are evolving the existing “weather” satellites into an integrated environmental observing system by expanding our capabilities to observe, assess, and predict the total Earth system – ocean, atmosphere, land, and the space environment. Data from the advanced sensors will be available four times faster than today significantly improving forecasts and serving data continuity requirements for improved global climate change assessment and prediction.

5.1.2 Requirements

NOAA, DOD, and NASA agreed upon a set of integrated operational requirements that will meet the needs of the U.S. civil and military users for operational satellite data. The military and civilian user communities jointly defined Environmental Data Records (EDRs), as well as the required performance characteristics for each of these data products. The established requirements for 38 atmospheric, oceanic, terrestrial, climatic, and solar-geophysical parameters are guiding the development of advanced technology visible, infrared, and microwave imagers and sounders that will provide enhanced capabilities to users and improve the accuracy and timeliness of observations. The data for the 38 EDRs that will be collected by the suite of instruments encompass the Earth science disciplines.

Performance characteristics for each of the 38 EDRs were defined and bounded between threshold values that represent minimally acceptable performance for an attribute and objective levels that represent performance that would have significant added value to users. In many cases, threshold values were set to meet or exceed what can be achieved from instruments on current operational satellites (i.e., POES, MetOp, and DMSP). The specific attributes include horizontal and vertical resolution, mapping accuracy, measurement range, measurement precision, measurement uncertainty, refresh rate, data latency, and geographic coverage. Long-term stability requirements have been established for key parameters (e.g., atmospheric vertical temperature, sea surface temperature, sea surface winds) to ensure temporal consistency and continuity of data. These stability requirements have influenced the design and performance of the advanced technology sensors that are being built and are guiding the development of the calibration/validation activities.

5.1.3 Instruments and System Development

The operational weather forecasting and climate science communities have levied rigorous requirements on space-based observations of the Earth's system. These requirements have increased demands on performance of the instruments, spacecraft, and ground systems required to deliver data, products, and information to end users. Instruments will observe significantly more phenomena simultaneously from space than their POES and DMSP predecessors. Observatories will deliver more accurate measurements at higher spatial (horizontal and vertical) resolutions to support operations and research. User demands for more real-time data are driving the space and ground-based architectures for data routing and retrieval that will dramatically shorten data latency (time from observation by the satellite to availability of processed EDRs). NOAA will deliver data from its advanced technology visible, infrared, and microwave imagers and sounders at higher data rates with more frequent space-to-ground data communications. Most of the sensors are considerably more complex and have data rates that are two orders of magnitude greater than the instruments carried on either DMSP or POES.

To support the converged civil and military requirements for space-based, remotely sensed environmental data, the spacecraft (depending upon orbit) **<u>may</u>** carry the following sensor payloads:

> <u>Visible/Infrared Imager/Radiometer Suite (VIIRS):</u> The VIIRS will combine the radiometric accuracy of the AVHRR/3 currently flown on the NOAA polar-orbiters with the high spatial resolution (0.65 km) of the Operational Linescan System (OLS) flown on DMSP spacecraft. The VIIRS will have 22 channels grouped into the panchromatic day/night band, visible and near-infrared (IR), short and mid-wave IR, and long-wave IR. VIIRS spectral bands are characterized as either fine spatial resolution or moderate spatial resolution. Fine resolution bands will have horizontal sampling intervals (HSIs) of about 400 m to 800 m across the ~3000 km swath and moderate resolution bands will have HSIs of twice this size. VIIRS will provide measurements of sea surface temperature, atmospheric aerosols, snow cover, cloud cover, surface albedo, vegetation index, sea ice, and ocean color. VIIRS is expected to perform similarly to MODIS on NASA's Earth Observing System (EOS) Terra and Aqua missions in many of the spectral bands. VIIRS represents a significant step in transforming NASA's state-of-the-art research sensors into operational sensors to meet the needs of both the operational and research communities.

> <u>Cross-track Infrared Sounder (CrIS):</u> The CrIS is a Fourier Transform Spectrometer that uses a Michelson interferometer sounder capable of sensing upwelling infrared radiances from 4 to 16 m at very high spectral resolution (~1300 spectral channels) to determine the vertical atmospheric

distribution of temperature, moisture, and pressure from the surface to the top of the atmosphere. The CrIS uses an array of 9 Fields of View (FOV), each 14 km in diameter and each spanning 3 IR bands. CrIS will provide data across a 2200 km swath that will be combined with data from passive microwave instruments to construct atmospheric temperature profiles at 1° K accuracy for 1 km layers in the troposphere and moisture profiles accurate to 15 percent for 2 km layers.

Advanced Technology Microwave Sounder (ATMS): The ATMS is the next generation cross-track microwave sounder that will combine the capabilities of current generation microwave temperature sounders (AMSU-A) and microwave humidity sounders (AMSU-B/MHS/Humidity Sounder for Brazil (HSB)) that are flying or will be flown on NOAA's POES, NASA's EOS Aqua, and EUMETSAT's MetOp spacecraft. The ATMS draws its heritage directly from AMSU-A/B, but with reduced volume, mass, and power. The ATMS has 22 microwave channels to provide temperature and moisture sounding capability in the 23/31, 50, 89,150, and 183 GHz spectral range.

Microwave Imager/Sounder (MIS): The MIS expected to be on the DWSS will combine the microwave imaging capabilities of Japan's Advanced Microwave Scanning Radiometer (AMSR) on NASA's EOS Aqua mission and the atmospheric sounding capabilities of the Special Sensor Microwave Imager/ Sounder (SSMI/S) on the remaining series of DMSP satellites, the first of which (DMSP F-16) was launched on 18 October 2003, with the polarimetric capabilities of the WindSat sensor on the Coriolis mission that was launched in January 2003. The MIS will use a rotating reflector to make "all-weather" measurements across a large frequency range of 6 to 183 GHz. Polarization for selected imaging channels will be used to derive ocean surface wind vectors. MIS data will be used to derive a variety of parameters, including all-weather sea surface temperature, soil moisture, precipitation, cloud liquid water, cloud base height, snow water equivalent, sea surface winds, atmospheric vertical moisture profile, and atmospheric vertical temperature profile.

Ozone Mapping and Profiler Suite (OMPS): The OMPS will consist of a nadir wide field-of-view push broom mapper similar in functionality to NASA's Total Ozone Mapping Spectrometer (TOMS) that will be able to provide ozone profiles with a vertical resolution similar to the present 7 to 10 km for the SBUV on POES.

Space Environment Monitor (SEM): SEM is the complement of sensors and algorithms used to measure the characteristics of the space environment that is carried on board the current generation of POES and MetOp satellites. DMSP and DWSS will continue the heritage of this mission

Search and Rescue Satellite Aided Tracking System (SARSAT): The SARSAT receives distress signals from emergency position indicating radio beacons (e.g. EPIRBs) on international distress frequencies and retransmits them to local user terminals for action by appropriate government agencies. The redesigned SARSAT subsystems will only support EPIRBs transmitting at 406 MHz.

Advanced Data Collection System (A-DCS): The A-DCS (ARGOS) relays meteorological and other data transmitted from *in-situ* ground-based data collection platforms including buoys, free floating balloons, and remote weather stations. The ARGOS-3/4 data collection system will provide two-way messaging capabilities for users to command and manage platform transmitters and sensors, as well as receive data efficiently from their platforms.

Cloud and Earth Radiant Energy System (CERES): The CERES measures the reflected shortwave and Earth emitted radiances. The CERES measurements seek to develop and improve weather forecast and climate models prediction, to provide measurements of the space and time distribution of the Earth's Radiation Budget (ERB) components, and to develop a quantitative understanding of the links between the ERB and the properties of the atmosphere and surface that define the budget.

Total Solar Irradiance Sensor (TSIS): TSIS measures the total solar irradiance (density of radiation on a given surface) and the spectral dispersion of that irradiance. Provides key insights into the Earth's radiation budget.

Fault tolerant designs for each of the instrument payloads should enable long mission life (up to 8 years storage and 7 years of operations) to ensure mean mission durations exceeding five years for each of the spacecraft.

5.1.4 Early System Testing

The NPOESS Preparatory Project (NPP) satellite, that will be launched in October 2011, will carry four critical sensors (VIIRS, CrIS, OMPS, and the NASA-developed ATMS) as well as CERES to provide on-orbit testing and validation of sensors, algorithms, and ground-based operations and data processing systems while the current operational POES, MetOp, and DMSP and the NASA EOS research satellite systems are still in place. In addition to ATMS, NASA is providing CERES and the NPP spacecraft that was built by Ball Aerospace and Technologies Corporation, as well as the launch service. NOAA is responsible for the VIIRS, CrIS, and OMPS instruments, NPP spacecraft operations, and ground processing systems.

In cooperation with the Norwegian Space Centre (NSC) a 13-meter antenna has been installed at Svalbard, Norway as the primary data downlink site for global stored mission data from NPP. Global stored mission data from NPP will be broadcast at X-band frequencies (8212.5 MHz) using a bandwidth of 375 MHz at a data rate of 300 Mbps. In addition to the stored data, 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. The Svalbard site is ready for NPP ground system readiness. Two fiber-optic cables from Norway to Svalbard will serve as the primary data routing path for NPP. Subsequent to the NPP mission, the Svalbard site and the high-speed fiber-optic link will serve as a primary site for telemetry and command and as one node in a globally-distributed ground data communications system.

The NPP mission will provide early access to the next generation of operational sensors, thereby greatly reducing the risks incurred during the transition from POES. Development risk for the ground systems is being reduced through early delivery and testing of the NPP ground system. Extensive pre-launch and on-orbit calibration and validation of instruments on NPP and early user evaluation of data products will allow for modifications to algorithms prior to the first JPSS launch. NPP will demonstrate the utility of the improved imaging and radiometric data in short-term weather "nowcasting" and forecasting and in other oceanic and terrestrial applications, such as harmful algal blooms, volcanic ash, and wildfire detection.

In addition to serving as a valuable risk reduction and prototyping mission, NPP will provide continuity of the calibrated, validated, and geo-located NASA EOS Terra and Aqua systematic global imaging and sounding observations for NASA Earth Science research. With a five-year design lifetime, NPP will provide a "bridge" from NASA's EOS research missions (Terra, Aqua, and Aura) to the operational JPSS mission. NPP will extend the series of key measurements in support of long-term monitoring of climate change and of global biological productivity.

5.1.5 Operations

The operational concept for JPSS consists of a constellation of spacecraft flying at an altitude of 833 km in a sun-synchronous (98.7 degree inclination) orbital plane with equatorial ascending nodal crossing time of 1330 local solar time. Spacecraft will be designed for precise orbit control to maintain altitude, nodal crossing time to within +10 minutes throughout the mission lifetime, and repeat ground tracks to +1 km (repeat cycles of ~17 days) for certain measurements.

NOAA plans to continue cooperation with EUMETSAT for a Joint Polar System (JPS). During the transition to a future international polar satellite program, EUMETSAT's MetOp-3 satellite will occupy the mid-morning orbit (0930). Use of data from EUMETSAT's MetOp satellite will increase the global coverage and refresh rate of the U.S. polar satellite system. In addition, the European meteorological community will receive valuable data from instruments on both the MetOp and JPSS satellites. The planning launch dates for the JPSS series of spacecraft are as follows:

NPP	Oct	2011	1330 (A)
JPSS-1	Nov	2016	1330 (A)
JPSS-2	Nov	2021	1330 (A)

5.1.6 Ground Systems

Global Data

To meet U.S. user-validated requirements for 38 geophysical parameters, including requirements for data latency, the ground segment will deliver global Stored Mission Data (SMD) to four U.S. Operational Processing Centers (Centrals) for processing and distribution. These Centrals are: NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) and National Centers for Environmental Prediction (NCEP); the Air Force Weather Agency (AFWA); Fleet Numerical Meteorology and Oceanography Center (FNMOC); and the Naval Oceanographic Office (NAVOCEANO). 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, transmitting at a data rate of 150 Mbps) that will be tied to Centrals via commercial fiber-optic networks. This NGAS/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 Environmental Data Records (EDRs) at the Centrals. Each Central will be equipped with an Interface Data Processing (IDP) segment consisting of the necessary data ingest and computational hardware/software to process Raw Data Records (RDR) into EDRs, using auxiliary and ancillary data as necessary. Intermediate-level satellite instrument Sensor Data Records (SDRs) will be produced as the RDRs are processed into EDRs. The SDRs contain the counts and calibration data at geo-located points. RDRs will also be provided by the IDP segment for archive and validation purposes. These data products will be available through the Centrals' IDP segment as retrievable data records.

Data, including RDRs, SDRs, EDRs, stored raw mission data, stored and real-time telemetry, and stored data from the A-DCS, will be distributed through the data routing and retrieval component of the ground segment to the four U.S. Centrals and to the two mission management/control centers. The primary Mission Management Center (MMC) will be located at the NOAA Satellite Operations Facility in Suitland, Maryland. An alternate MMC will be located in Aurora, Colorado. The Centrals' IDP segment 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 NESDIS will maintain the long-term archive.

Direct Broadcast Services

In addition to the space-to-ground transmission of SMD, JPSS 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 RDRs into EDRs by using IDP segment software appropriate for the type of field terminal. IDP segment software will be developed 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. NOAA will distribute non-proprietary IDP segment field terminal software, software changes, and program updates through NOAA's Comprehensive Large-Array Storage System to field terminal users worldwide.

The High Rate Data (HRD) broadcast will be a complete, full resolution data set containing sensor data and auxiliary/ancillary data necessary to generate EDR's 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, with a tracking receive antenna aperture not to exceed 2.0 meters in diameter.

The Low Rate Data (LRD) broadcast planned for JPSS-2 will be a subset of the full 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). Some data compression (lossy or lossless) may be employed for the LRD link. The LRD L-band broadcast will provide data at a rate of about 4.0 Mbps (nominally 3.88 Mbps) at 1707 MHz, using a bandwidth of 8 MHz, 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 LRD parameters (frequency, bandwidth, data rate, and data content) have been selected to satisfy U.S. requirements for low-rate, real-time direct broadcast, as well as to be closely compatible with (but not identical to) the broadcast parameters for the Advanced High Resolution Picture Transmission (AHRPT) format that has been accepted and approved by the Coordinating Group on Meteorological Satellites (CGMS) and will be used on the EUMETSAT MetOp spacecraft. The LRD broadcast will include data required to satisfy the U.S. user-specified, eight highest priority EDRs for real-time broadcast: imagery (from VIIRS) at 800 m from at least one visible and one infrared channel and night time imagery at 2.7 km from the day/night band; atmospheric vertical temperature and moisture profiles (from CrIS, ATMS, and CMIS); global sea surface winds (from CMIS); cloud base height, cloud cover/layers; pressure (surface/profile), and sea surface temperature. Additional lower priority EDRs will also be included in the LRD broadcast. Future communications capabilities (e.g., rebroadcast of processed imagery/data and delivery via the Internet or "commercial" services) may allow other-than-direct satellite-to-ground data transmission to follow-on field terminal systems.

The NPP direct broadcast downlink will be at 7.812 GHz supporting a 15 Mbps data rate. The NPP SMD downlink will be at 8.2125 GHz supporting a 300 Mbps data rate. The NPP direct readout ground system with acquisition and processing capabilities for High Rate Data (HRD) will be known as the NPP In-Situ Ground System (NISGS). NISGS enables the user community to transition from existing POES/Terra/Aqua direct broadcast data to NPP and JPSS HRD data. Build 5 of NISGS will be provided to the public three months after launch. Direct readout station interface requirements and RF interface control documents for NPP can be found at the following URLs:

http://directreadout.sci.gsfc.nasa.gov/links/rsd_eosdb/PDF/NPP_IRD_DB.pdf

http://directreadout.sci.gsfc.nasa.gov/links/rsd_eosdb/PDF/NPP_HRD_RFICD_CH02.pdf

6. SUMMARY

Plans and programs are in place to provide continuous polar-orbiting satellite coverage into the 21st century. Significant progress that has been made towards implementing these plans: the successful launch of NOAA-N Prime (NOAA-19) in February 2009; the launch of the first MetOp satellite in 2006; and the establishment of the “Joint Polar Satellite System” (JPSS). The advanced technology visible, infrared, and microwave imagers and sounders will deliver higher spatial and temporal resolution oceanic, atmospheric, terrestrial, climatic, and solar-geophysical data, enabling more accurate short-term weather forecasts and severe storm warnings. The improved accuracy in atmospheric temperature and humidity soundings from these instruments, in combination with other observations expected to become available will enable the current 3- to 5-day short-term weather forecasts to be improved from 70 to 80 percent to better than 90 percent and to be extended from 5 to 7 days with 80-percent accuracy. Continuity of critical data for monitoring, understanding, and predicting climate change and assessing the impacts of climate change on seasonal and longer time scales will be maintained and help us “take the pulse of Planet Earth”. These activities represent a sound beginning for achieving the planned national and international operational satellite programs that will ensure continuous support to a variety of users into the 21st century.