2.1 AN OVERVIEW OF THE INITIAL JOINT POLAR-ORBITING SYSTEM (IJPS) AND ITS IMPACT ON THE NOAA/NESDIS POES PROGRAM

Diane Holmes* and Stacy L. Bunin
Mitretek Systems, Inc., Falls Church, Virginia

H. James Silva
NOAA/NESDIS, Washington, D.C

1. INTRODUCTION

The overall mission objectives of the Polar-orbiting Operational Environmental Satellite (POES) system are to provide continuous 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. To fulfill these mission objectives, the National Environmental Satellite, Data, and Information Service (NESDIS), part of the National Oceanic and Atmospheric Administration (NOAA), has operated the current POES system since 1978, with a two satellite constellation in circular, near-polar, sun synchronous morning (7:30AM) and afternoon (2:00PM) orbits. However, the POES program is undergoing a transformation. The POES system is transitioning to the Initial Joint Polar-orbiting System (IJPS). IJPS will be a means for sharing polar satellite assets between the US and Europe.

IJPS is a cooperative effort between the United States and the Europeans to share responsibility for polar satellite operations and derived products. The details of IJPS can be found in The Agreement Between the United States National Oceanic and Atmospheric Administration and the European Organization for the Exploitation of Meteorological Satellites on an Initial Polar-orbiting Operational Satellite System, signed in November 1998. IJPS will be supported by US satellites, NOAA-N and -N', in the afternoon orbit and European satellites, MetOp-1 and -2, in the mid-morning orbit. As part of the IJPS agreement, NOAA and EUMETSAT are required to support each other's operational satellite through their respective ground segments for commanding, receiving telemetry and global data, monitoring their respective on-orbit status, and exchanging data between the two polar satellite systems. In order to meet the requirements of IJPS, the NOAA Polar Ground System is undergoing numerous changes. This paper provides an overview of several elements of IJPS with a focus on the changes to and the benefits of IJPS on the NOAA Polar Ground System.

* *Corresponding author address*: Diane Holmes, Mitretek Systems; 3150 Fairview Park Drive South; Fall Church, Virginia 22042; e-mail: DHolmes@Mitretek.org.

2. CURRENT STATUS/PLANS

NOAA currently operates a morning and an afternoon polar-orbiting series of weather satellites as part of the POES program. In the current series, NOAA-15 and NOAA-16 are the morning and afternoon satellites, respectively, and NOAA-M is planned for launch in March 2002 into a mid-morning orbit (10:00AM). A follow-on satellite series, NOAA-N and -N', are scheduled for launch in June 2004 and March 2008. NOAA monitors each satellite's orbit, health and safety data, and also provides direct readout and stored instrument science data to users.

MetOp-1 is scheduled for launch in 2005. Once it is declared operational in 2006, the MetOp satellite will assume the mid-morning orbit. EUMETSAT will be responsible for operating the MetOp-1 satellite as well as distributing the environmental data to its members. As part of the IJPS agreement, NOAA will receive environmental data from the common set of instruments carried on both the NOAA and MetOp satellites as well as the data from the MetOp unique instruments.

3. POES GROUND SYSTEM

The current POES ground system includes the following elements:

- Satellite Operations including:
  - CDA-Command and Data Acquisition Station (Fairbanks, AK and Wallops, VA)
  - SOCC- Satellite Operations Control Center (Suitland MD)
- Information Processing Systems including:
  - CEMSCS- Central Environmental Meteorological Satellite Computer System Suitland, MD
- Product Generation and Distribution
- Archive including:
  - NCDC- National Climatic Data Center, Asheville, North Carolina,
  - NODC- National Oceanographic Data Center, Silver Spring, Maryland
  - SAA- Satellite Active Archive, Suitland, MD

Satellite health and safety and instrument science data are received at the CDAs and then transmitted to the SOCC via a DOMSAT link. The SOCC processes

satellite health and safety data and sends instrument science data to the CEMSCS for information/product processing. The CEMSCS ingests the Level 0 data and processes it to NOAA Level 1b data sets (raw instrument data with ancillary data appended). The Level 1b data sets are then accessed by numerous product processing systems for environmental product generation (NOAA Levels 2 and 3) and near real-time distribution to users. Level 1b and selected products are available via the SAA. All NOAA Level 1b and operational data sets are transmitted to the NOAA data centers for long term archiving and distribution.

NOAA's participation in IJPS will require upgrades to the existing POES ground system due to the differences between the POES and MetOp satellites and the new interface requirements. These upgrades will address new instruments, new operating modes, and new technologies which are part of IJPS.

3.1 Instruments

During IJPS, NOAA-N and -N' and MetOp-1 and –2 will carry a common set of core instruments. These instruments include: AVHRR/3, HIRS/4, AMSU-A, MHS, SEM/2, SARSAT, and DCS. In addition to the core instruments, each satellite will carry instruments unique to its mission. For the NOAA satellites, the unique instrument is the SBUV/2. The MetOp-unique instruments are:

- Infrared Atmospheric Sounding Interferometer (IASI) which will retrieve high resolution atmospheric profiles of temperature and humidity with its 8461 channels
- Global Ozone Monitoring Experiment (GOME) which is an ozone profiler and total ozone measurement instrument
- Global Navigation Satellite System Receiver for Atmospheric Sounding (GRAS) which is a GPS type atmospheric sounding system
- Advanced Scatterometer (ASCAT) which is an instrument for measuring sea surface wind speed and direction.

Additionally, the MetOp spacecraft will have the capability to record full resolution 1km global data from the AVHRR/3. NOAA will continue to provide 4km global data from the AVHRR/3 throughout IJPS.

The common and unique instruments will require changes/upgrades to polar ground systems throughout NESDIS. The POES ground system will have the ability to control all instruments on the POES satellites, regardless of origin, to maintain the safety of the instrument and satellite as well as ensure that the common set of environmental instruments continue to collect and provide meteorological data. Modifications to current product processing systems will accommodate the changes associated with processing of satellite instrument data from the NOAA instruments on the MetOp satellite as well as the four MetOp-unique instruments. New algorithms will be developed for the MetOp-unique instruments so that data from these instruments can be used to produce new and improved products. Upgrades to NCDC, NODC, and SAA are required to support the increased data volume associated with MetOp 1km AVHRR and products from the four new MetOp instruments.

3.2 Satellite Operations

Via the SOCC and CDAs, the POES ground system will have the ability to command, control, and receive data from both the NOAA and MetOp satellites. Similarly, EUMETSAT will have the capability to support the MetOp and NOAA satellites from a control center in Darmstadt, Germany and a CDA station in Svalbard, Norway. At each control center, an interface will be established as a single point of entry through which all environmental data, health and safety data for satellites and instruments, satellite commands, and general voice communications will pass.

During IJPS, NOAA and EUMETSAT will provide cross-support during various operating scenarios. Two such scenarios are blind orbit and contingency operations.

Blind Orbit Support: Until IJPS is implemented, data acquired during POES blind orbits, i.e. orbits in which the satellite is not visible from the Fairbanks or Wallops CDA stations, is stored on the satellite and retrieved on the next visible pass. This results in the data not meeting the timeliness requirements established by the user community. To meet the user timeliness requirements, Level 2 products must be made available within 3 hours of observation. During IJPS, data from POES blind orbits will be retrieved at Svalbard and forwarded through Darmstadt to NOAA for processing. This blind orbit support will allow NOAA access to data from all orbits in near real-time thereby meeting the user timeliness requirements.

Contingency Support: During the IJPS era, the NOAA and EUMETSAT ground systems will have the capability to support each other's satellites in the event of an emergency or other contingency situations. In the case of contingency support for NOAA, health and safety data from the satellite/instruments as well as the environmental data will be downlinked to Svalbard and forwarded through Darmstadt to Suitland. The system will also allow NOAA to forward commands through the EUMETSAT ground system for transmission to the POES satellites via the Svalbard CDA. Similar capability will exist within the POES ground system to support MetOp satellites via the Fairbanks CDA.

While NOAA will benefit from having this virtual extension of its ground system, numerous upgrades are planned at the Fairbanks CDA and at SOCC to support the IJPS operations. Defining the upgrades to individual processing systems and supporting infrastructure is beyond the scope of this paper. However, at a minimum, the following functionality will be added to the POES ground system:

- Ability to receive, archive, and distribute to EUMETSAT all health and safety telemetry and global environmental data from the MetOp satellite;
- Ability to receive commands from EUMETSAT and transmit them to the MetOp satellite;
- Ability to receive, process, and distribute products derived from MetOp HRPT.

3.3 IJPS Technologies

IJPS will introduce several new technological advancements to the current POES ground system. While many of these advancements will be incorporated into the POES ground system for use during IJPS, many will be used in parallel with POES existing systems. These advancements include the following:

Pipeline Processing: Data will be delivered in pipeline mode to NOAA from EUMETSAT, which means data will be delivered in a constant flow as opposed to the current "burst" delivery method. Currently, POES data is received and stored at the CDA until all data for the pass has been downlinked. The data is then packaged together and "burst" back to SOCC. NESDIS will integrate pipeline processing into the POES ground system, providing the capability for processing NOAA data in the same mode.

Pipeline processing requires less bandwidth to transfer an equal amount of data. However, it is a much slower transfer process. To meet data timeliness requirements, the Svalbard CDA will begin to transfer the data almost immediately upon its receipt. Additionally, processing of the data will begin almost immediately upon its receipt at NOAA. MetOp data will arrive at the NESDIS ingestor in granules, or small subsets, of the orbit. Level 1 data will be produced in pipeline format to allow for the simultaneous processing of each granule to meet dataset timeliness requirements. The polar product processing systems will also process the Level 1 data into Level 2 products via a pipeline format in order to meet user timeliness requirements.

X-Band frequency data reception: Throughout IJPS, POES satellites will maintain S-band uplink and S- and L- band downlink capability. However, the MetOp satellites require X-band for downlinking data from the satellites. X-band downlink is required to accommodate the high rate unique instruments on the MetOp satellites, e.g. IASI.

X-band provides a much greater downlink capacity than L-band, yielding more data in the acquisition window. More data offers the potential to produce new and improved products.

CCSDS data format: MetOp data will utilize the Consultative Committee for Space Data Systems (CCSDS) standards. CCSDS is a communication protocol, optimized for satellite to ground communications. The CCSDS data format creates frames of fixed size, which are compatible with a forward error correction system. This system adds specially coded bits to each frame, which allows the ground system to identify errors in the data.

Creating parallel systems for processing X-band and CCSDS data formats will allow operators and engineers to expand their technical breadth and gain operating experience, which may reduce operational risks as NOAA moves into the next phase of Polar satellites, the National Polar-orbiting Operational Environmental Satellite System (NPOESS).

4. CONCLUSION

Activities are ongoing at NOAA to define and develop changes to the POES ground system that will allow NOAA to continue to meet its mission objectives and support the terms of the IJPS agreement. To ensure that NOAA is prepared to support IJPS operations, all upgrades, including a new communications system, archiving system, and data processing system, must be designed, integrated, and tested prior to the launch of MetOp-1.

IJPS will provide significantly improved operational capabilities and benefits to satellite heath and safety through the elimination of blind orbits and additional support during contingency situations. NOAA's participation in IJPS will form the baseline for future planned national and international Polar programs and ensures continuous support to a variety of users.

Additional IJPS information is available at the IJPS website: http://discovery.osd.noaa.gov/ijps/

REFERENCES

Mignogno, M. and J. Silva: *POES Program Status and NOAA Participation in the Initial Joint Polar Satellite System,* prepared for the MAXI Review 2001, September 18-20, 2001.

Silva, J. and L. A. Deem. *Transitioning the Polar-orbiting Operational Satellite Program to the New Millennium with Participation in the Initial Joint Polar-orbiting Operational Satellite System*, Preprints 14th IIPS, Phoenix, AZ, Amer. Meteor. Soc., paper 3.16.

Bunin, S. L., D. Holmes, and P. M. Taylor: *An Overview of the NOAA/NESDIS Product Processing Plans for the Initial Joint Polar System Era*, Preprints 18th IIPS, Orlando, FL, Amer. Meteor. Soc., paper 2.2.

Polar Operational Environmental Satellite Ground Segment Upgrade Description & Requirements for Initial Joint Polar Satellite System (RDN5), Version 1a, May 2000.

IJPS website: http://discovery.osd.noaa.gov/ijps/.