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THE INITIAL JOINT POLAR-ORBITING OPERATIONAL SATELLITE SYSTEM APPROACHES FIRST LAUNCH

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1. Introduction

The Initial Joint Polar-orbiting Operational Satellite System (IJPS) is unique because the National Oceanic and Atmospheric Administration (NOAA) and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) have partnered to provide the next four polar orbiting satellites. The joint agreement was signed in 1998. NOAA will develop and launch two afternoon satellites while EUMETSAT has agreed to develop and launch two morning satellites. Both partners have worked cooperatively to define requirements to create space and ground segments to meet the terms of the agreement. A system of this magnitude, four satellites, two international organizations, and the payloads, is complex with many challenges, and at this juncture, launch of the first satellite is only months away.

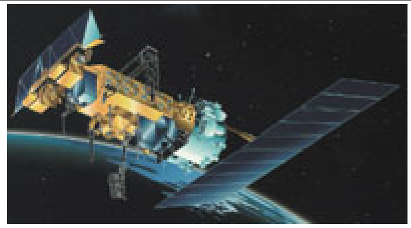
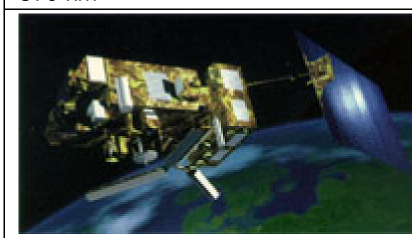
This paper is written from the NOAA ground segment (functional elements) perspective. The ground segment includes the Command Data Acquisition Station (CDAS), the Satellite Operation and Control Center (SOCC), the Communications Element (CE), Data Ingest and Preprocessing System (IPS), Navigation and Geolocation (N&G), Quality Trending, Instrument Calibration, Product Generation and Distribution (PGD), Archive and Access System (AAS), Documentation, and Verification and Validation (V&V). These sub-segments of the ground segment are further defined and the synergy identified that makes this system truly unique.

2. Description of IJPS

NOAA has a long, successful history with polar orbiting environmental satellites (POES) that date back to the early TIROS satellites in the 1960s and 1970s. The receipt and processing of polar orbiting satellite data are mature methods in NOAA, with some modifications, these methods are adaptable to the IJPS constellation of satellites.

The four satellites, NOAA-N and NOAA-N Prime and EUMETSAT's Metop 01 and 02, have slightly different characteristics as listed in Table 1.

Table 1. IJPS Spacecraft Characteristics

 **NOAA-N,-N'**
Height: 165 in (4.19m) Diameter: 74 in (1.88m) Solar array area: 180.6 ft² (16.8 m²)
4920 lbs (2231.7 kg)
879.9 W
> 2 years
Nominal Altitude: 870 km Inclination: 98.856 degrees Local Solar Time: 1340 (ascending node)
982.5 lbs (445.6 kg)
450 W
Ascending node: 1400
870 km
 **METOP-1,-2**
Height: 7.6m (299.21 in) Length: 6.8m (267.72 in) Width: 3.7m (145.67 in) Solar array length: 11.3m (37 ft)
9922.5 lbs (4500 kg)
3900 W
5 years
Near-polar sun-synchronous Mean Altitude: 840 km Local Solar Time: 0930 (descending node) 5 days repeat cycle
840 kg (1852.2 lbs)
980 W
Descending node: 0930
834.5 km

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There are three CDAS that are active to support IJPS services. Two sites that NOAA operates are at Wallops Island, VA, for data capture and backup support for SOCC, and the second at Fairbanks, AK for data capture and satellite telecommanding. The third site is operated by EUMETSAT and is located in Svalbard, Norway. This site is similar to Fairbanks in that the capabilities include data capture and telecommanding One of the unique aspects of IJPS is the ability for EUMETSAT to command Metop satellites through the Fairbanks station, and NOAA to command NOAA IJPS satellites through the Svalbard site.

Communication takes several forms including DOMSAT, communication lines on demand, local carriers, international private lines and a transatlantic link. The communication is used to move satellite data captured in Fairbanks to Suitland, MD and EUMETSAT, and satellite data captured in Svalbard to EUMETSAT and Suitland.

The raw sensor data received in Suitland, from both NOAA and Metop satellites, are ingested, navigated and earth located. The processed data are made available for product generation, distribution and archival.

The NOAA and EUMETSAT ground receiving systems have the ability to work as one integrated system for commanding and sharing satellite data. Therefore, there are numerous joint tests planned to ensure that the interface requirements are met and support the functionality between these two systems. Another AMS paper in this session, Crosiar, Srinivas, and Holt, 2005 describes the detail of such testing.

3. Instrumentation

The NOAA-N satellite payload is comprised of eight instruments, the Advanced Very High Resolution Radiometer/3 (AVHRR/3), High Resolution Infrared Radiation Sounder (HIRS/4), Advanced Microwave Sounding Unit (AMSU), Microwave Humidity Sounder (MHS), Solar Backscatter UltraViolet Instrument (SBUV/2), ARGOS/Data Collection System/2 (DCS/2), Search and Rescue Satellite (SARSAT) Aided Tracking System, and Space Environment Monitor-2 (SEM-2). These instruments are described in Silva and Deem, 1998.

The Metop payload carries the instrument suite of NOAA-N, excluding the SBUV/2, in addition to the following four instruments: Infrared Atmospheric Sounding Interferometer (IASI), Advanced Scatterometer (ASCAT), Global Navigation Satellite System Receiver for Atmospheric Sounding (GRAS), and Global Ozone Monitoring Experiment (GOME).

4. Ground Segment

The ground segments for NOAA and EUMETSAT are partner specific. Operations and control of NOAA-N and NOAA N Prime are handled through NOAA's SOCC and CDA's and EUMETSAT is responsible for the operations and control of Metop 01 and 02 through their Polar Command and Data Acquisition station in Svalbard, Norway and Mission Control and Support Center in Darmstadt, GE.

The upgrades, modifications, and new equipment on both sides of the Atlantic Ocean have started to appear in the operation's areas. Up-converters, down-converters, multi switches, Cortex units and PTP's are among the equipment needed for the commanding and contingency operations to backup the other partner.

The implementation of a NOAA "gateway" in Darmstadt allows all IJPS satellite data captured by EUMETSAT from Metop and blind orbits of NOAA to be transferred to Suitland. EUMETSAT plans to have a "gateway" in Suitland to receive the data from the two NOAA satellites as well as any contingency data from Metop and move these data to Darmstadt.

The progress of the two partners is reflected in the schedule. NOAA will launch the first of the IJPS constellation, NOAA-N, currently on the schedule for February 2005. All sub segments of the NOAA ground segment are ready to receive and process NOAA-N satellite data.

EUMETSAT is currently scheduled to launch the first IJPS morning satellite in December 2005. Although the NOAA CDA's and SOCC plan to be completed for Metop commanding and reception by the end of the 2004, the remainder of the sub segments need FY05 and half of FY06 for completion.

5. Availability of Data

The data from the morning and afternoon satellites of IJPS have distinctive characteristics from the legacy POES currently flying in the K-L-M series of satellites. EUMETSAT instruments, namely, MHS, IASI, GRAS and GOME have distinctive characteristics because Metop will be the first time these instruments are flown.

The NOAA POES data users are familiar with the 1 km spatial resolution of the AVHRR data in Local Area Coverage and High Resolution Picture Transmission. The stored global area coverage data transmitted from recorders on board the satellite is at a spatial resolution of 4km. The EUMETSAT morning satellite, Metop, will provide a Global Data Stream (GDS) that is 1km resolution.

The IJPS NOAA N data will be captured at all three CDA's. The instrument data are ingested and navigated. From that point the data are distributed to the users and also archived. The products that NOAA/NESDIS creates for customers are defined in two papers, Bunin, et.al, 2002, and 2003.

The archive of the satellite data is in NOAA's National Environmental Satellite Data Information Service called Comprehensive Large Array-data Stewardship System (CLASS), web address: http://www.class.noaa.gov. The satellite data and products that are archived are available to users, currently at no charge.

All IJPS data that CLASS archives includes all data from instruments on the IJPS NOAA and EUMETSAT satellites.

6. Joint Testing

Before the Metop satellite launches both NOAA and EUMETSAT plan to test the requirements and functionality of the two ground segments that in a certain respect act as one system. The preliminary tests that test the connectivity of the two ground segments are to start before the end of calendar year 2004.

The following phase of testing covers the phase called the Group 1 tests. Here satellite data flows from one partner to the other. Communication connectivity is tested and the ingestion of the Metop data by NOAA and reciprocal processing of NOAA data ingested by EUMETSAT is also tested. This phase includes ten tests and is planned for a four to six week period, March through April 2005.

The last phase of pre launch joint testing is called Group 2 tests. These tests are conducted on an operational basis. The connectivity and the passing of data is tested in Group 1, this phase tests the ability of the two ground segments to actually function in an operational setting.
The detail of the joint testing between NOAA and EUMETSAT is available in the Crosiar, Srinivas and Holt, 2005 paper.

7. Challenges in System Integration

Systems that are large and have a variety of sub segments, by nature of their size, present challenges to the final integration. There are a large number of companies and people that are extremely important to the final integration. The contractors and sub contractors that are on contract to deliver certain pieces of the system are vital to the success of the system. If they suffer delays, due to any number of reasons, these are challenges in the integration of the system.

7.1 Equipment Design Problems

Equipment requirements place challenges on the developer to design and build equipment to meet the requirements. Occasionally, the requirements describe new limits for equipment or new capabilities. Although the contractor is confident they can meet the requirements in the design phase, the implementation proves those new capabilities are unattainable.

Another problem on equipment design is the inability to extract the necessary information for a piece of equipment to function properly. Of course, the earlier this is discovered the better, however, this may first be recognized when the new equipment is tested and doesn't work.

The first problem is easier to resolve. The government, in this case, can supply a waiver on the deliverable that allows the equipment to have reduced capabilities. There is a minimal impact to schedule. The second problem mentioned is a more difficult one to solve. The new equipment must work to meet the requirement. Without the equipment the information doesn't move. With this problem, the only resolution is to correct the error. This type of problem impacts schedule. One solution to alleviate the impact to schedule is to test the equipment as early as possible. This maximizes the available time to work out problems with the least amount of impact to the schedule.

7.2 Ingest and Preprocessing System-Generic File Transfer

Another challenge to system integration is that all the pieces converge near simultaneously. In the age of information technology there are needs, requirements and concerns that focus on the access to a network. Those issues produce a certain level of overhead that is manifested in routers, firewalls, IP addresses, servers and clients to name a few. There are auxiliary and peripheral data that are exchanged between the partners that are needed for ingest and preprocessing. These data are exchanged through a generic file transfer.

In order for each partner to be able to protect their networks, the servers must be able to not only transfer the appropriate data but also only provide trusted users to gain access. These requirements must be analyzed for a sound working solution. Once a solution is identified, the hardware and software must be purchased and developed, respectively.

Although the entire generic file transfer effort may only take six weeks to put into operation, that time lag can impact a tight test schedule. The challenge for system integration is to ensure a six-week effort doesn't hold up a half-year testing effort.

This challenge like the first one previously mentioned has two commonalities. The first is that each impacts schedule. Secondly, the fundamental resolution to these challenges is personnel. People are the key components to solve design problems and to bring the necessary pieces in place for system completion. The technically correct person in place willingly and able to step up to meet the challenge is what system integration, what successful system integration is all about. At NOAA NESDIS the Ground Segment Team for IJPS is focused and dedicated to meet the mission for both NOAA and EUMETSAT.

8. Launches on the Horizon

The two NOAA satellites, NOAA N and N Prime, are scheduled to launch Feb 2005 and Dec 2007, respectively. EUMETSAT has Metop 1 scheduled for Dec 05 and Metop 2 for Jan 2010. These satellites are the interim satellites that fall between NOAA's K, L, M series and the upcoming NPOESS suite of satellites.

8.1 NOAA-N

For NOAA-N's launch, the operations tempo increases six months prior to launch as the satellite's instruments are tested in their launch configuration, as launch simulations are run to test procedures and computer systems, as satellite and booster are transported to launch facility and rehearsals are orchestrated to exercise sequences and processes for all steps leading to lift off.

As every sector is important for a successful satellite launch, the ground segment is most critical during the life of the satellite. The ground system sector monitors the instrument and satellite health and safety, receives data from the satellite, transmits the data for processing and commands the satellite through the control center.

For the NOAA N launch, the NOAA Ground Segment is ready to support those aforementioned activities. Processing the data for the NOAA instruments are on track for Jan 05. There is a commissioning process before the satellite is made operational.

The NOAA-N Prime satellite is a clone of the NOAA-N, that means the systems in place to process NOAA-N will also be able to process NOAA-N Prime.

8.2 Metop

The first launch of a Metop satellite is still over a year away. Although the NOAA CDA's near completion for the Metop commanding and reception, there remains work to be done in the areas of ingest and preprocessing, data product generation and distribution, and data archive. Those areas of the NOAA ground system are scheduled to complete well in advance of launch. In fact, joint testing will begin for NOAA with EUMETSAT the end of March 05.

The tests will ensure data can be captured and transferred to the correct location, processed and products produced. The data processing into products is scheduled to be completed prior to Metop launch.

Metop has a six-month commissioning process. At the end of a successful commissioning process the satellite is operational. With that designation all aspects of the satellite are functional and the ground system is certified operational with the satellite.

The second Metop is a carbon copy of the first, as are the NOAA-N and N Prime satellites. That also means the systems in place to process Metop 01 will be used to process Metop 02.

9. Summary

The IJPS project is unique due to the international scope of the polar orbiting satellite system. Coordination of the ground system for the NOAA and Metop satellites has been challenging through the design phases of the project, but now coordination has reached a new level of challenge and excitement. Installation of hardware and software on both sides of the Atlantic Ocean require new levels of cooperation. Joint testing requires new rules for review boards and time lines. Test participants are separated spatially by nearly 10,000 miles. These examples should provide evidence to types of challenges that await the project.

This glimpse of the actions necessary for the IJPS constellation to progress from an agreement made in 1998 to satellites orbiting the poles in 2005 as a significant contribution to the meteorological customers of the United States and the European Organization for the Exploitation of Meteorological Satellites.

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