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**Polar Operational Environmental Satellite (POES)  
Geostationary Operational Environmental Satellite (GOES)**

The National Oceanic and Atmospheric Administration (NOAA) manages a constellation of six geostationary and twelve polar orbiting meteorological spacecraft, including six military satellites, from the Satellite Operations Control Center (SOCC) in Suitland, Maryland. These satellites provide continuous observations of weather conditions and environmental features of the western hemisphere, monitor global climate change, verify ozone depletion and land surface change, monitor the critical space environmental parameters, and support search and rescue efforts across the globe. This document briefly addresses the status of the geosynchronous and low-earth-orbiting spacecraft constellations as of October 2, 2006

## **Polar Operational Environmental Satellite (POES) Geostationary Operational Environmental Satellite (GOES)**

### **1. Report on the Status of Current Satellite Systems**

#### **1.1 Polar Orbiting Meteorological Satellite Systems (POES)**

The POES spacecraft constellation includes two primary, one secondary, two standby and one non-operational spacecraft. These spacecraft are in circular orbits inclined at approximately 98 degrees (retrograde). The primary operational spacecraft, NOAA-18 and NOAA-17, are in sun-synchronous afternoon and morning orbits, respectively. Two secondary spacecraft, NOAA-16 and NOAA-15 provide additional payload operational data. NOAA-12 and NOAA-14 are standby spacecraft supporting additional user data requirements.

The next POES launch, NOAA-N' is slated for launch in December 2007. This spacecraft, which will be renamed NOAA-19 once it achieves orbit.

#### **NOAA-18**

NOAA-18 was launched on May 20, 2005. As of August 30, 2005, NOAA-18 was designated operational. It replaced NOAA-16 as a primary spacecraft. As such, it operates in an orbit with a 1:35 pm ascending node (afternoon orbit) and utilizes the Microwave Humidity Sounder (MHS) and the Solar Backscatter Ultraviolet Spectral Radiometer (SBUV). Since launch the High Resolution Infrared Radiation Sounder (HIRS) has experienced high noise in the long wave channels.

The NOAA-18, or afternoon mission, instrument payload includes:

- The Advanced Very High Resolution Radiometer (AVHRR/3), a six channel imaging radiometer which detects energy in the visible and near-IR portions of the electromagnetic spectrum. This data is used to observe vegetation, clouds, lakes, shorelines, snow, aerosols and ice.
  - The High Resolution Infrared Radiation Sounder (HIRS/4), which detects and measures energy emitted by the atmosphere to construct a vertical temperature profile from the Earth's to an altitude of about 40 km. These measured energy profiles are used to determine ocean surface temperatures, total atmospheric ozone levels, precipitable water, cloud height and coverage and surface radiance. There is an improvement of 20-km from the HIRS/3 instrument.
- X The Microwave Humidity Sounder (MHS) is a new instrument for the NOAA satellites. It is a five-channel microwave instrument intended primarily to measure profiles of atmospheric humidity. It is also sensitive to liquid water in clouds and so measures cloud liquid water content. Additionally, it provides qualitative estimates of the precipitation rate.

- The Advanced Microwave Sounding Unit-A (AMSU-A), which measures scene radiance in the microwave spectrum. The data from this instrument is used in conjunction with the HIRS to calculate the global atmospheric temperature and humidity profiles from the Earth's surface to the upper stratosphere, approximately a 2 millibar pressure altitude (48 km or 28 miles).
- The Space Environmental Monitor (SEM/2) provides measurements to determine the intensity of the Earth's radiation belts and the flux of charged particles at the satellite altitude. It provides the knowledge of solar terrestrial phenomena and also provides warnings of solar wind occurrences that may impair long-range communication, high-altitude manned operations, or disrupt satellite operations.
- The Search and Rescue (SAR) instruments are part of the international COSPAS-SARSAT system designed to detect and locate Emergency Locator Transmitters (ELTs), Emergency Position-Indicating Radio Beacons (EPIRBs), and Personal Locator Beacons (PLBs) operating at 121.5, 243, and 406 MHz. All spacecraft since NOAA-15 carry two instruments to detect these emergency beacons; the Search and Rescue Repeater (SARR) provided by Canada, and the Search and Rescue Processor (SARP-2) provided by France.
- The Data Collection System (DCS) collects and processes measurements from remote data collection platforms for on-board storage and subsequent transmission from the satellite. Data collection platforms in the form of buoys, free-floating balloons, and remote weather stations transmit their data on a 401.65 MHz uplink to the spacecraft. The DCS is used to gather environmental measurements such as atmospheric temperature and pressure, rainfall and snowfall, and velocity and direction of the ocean and wind currents.
- The Solar Backscatter Ultraviolet Spectral Radiometer (SBUV) is used to measure solar irradiance (backscattered solar energy), total ozone concentrations, and the vertical ozone profile in the atmosphere.

## **NOAA-17**

NOAA-17 was launched on June 24, 2002. As of October 15, 2002, NOAA-17 was designated operational. It replaced NOAA-15 as a primary spacecraft. As such, it operates in an orbit with a 10:20 a.m. ascending node (morning orbit) and utilizes a Solar Backscatter Ultraviolet Spectral Radiometer (SBUV). On February 15, 2003, DTR5 failed to operate and on April 28, 2003, STX3 power degraded to 2 watts. On October 28, 2003, the AMSU-A1 scan motor failed thus the instrument no longer provides any data. All other systems are operational.

The NOAA-17, or morning mission, instrument payload includes:

- The Advanced Very High Resolution Radiometer (AVHRR/3), a six channel imaging radiometer which detects energy in the visible and near-IR portions of

the electromagnetic spectrum. This data is used to observe vegetation, clouds, lakes, shorelines, snow, aerosols and ice.

- The High Resolution Infrared Radiation Sounder (HIRS/3), which detects and measures energy emitted by the atmosphere to construct a vertical temperature profile from the Earth's to an altitude of about 40 km. These measured energy profiles are used to determine ocean surface temperatures, total atmospheric ozone levels, precipitable water, cloud height and coverage and surface radiance
- The Advanced Microwave Sounding Unit-A (AMSU-A), which measures scene radiance in the microwave spectrum. The data from this instrument is used in conjunction with the HIRS to calculate the global atmospheric temperature and humidity profiles from the Earth's surface to the upper stratosphere, approximately a 2 millibar pressure altitude (48 km or 28 miles). The AMSU-A is also complemented by the AMSU-B, which is designed to allow the calculation of the vertical water vapor profiles from the Earth's surface to about a 200 millibar pressure altitude (12km or 7.5 miles). The data from these instruments is used to provide precipitation and surface measurements including snow cover, sea ice concentration, and soil moisture.
- The Space Environmental Monitor (SEM/2) provides measurements to determine the intensity of the Earth's radiation belts and the flux of charged particles at the satellite altitude. It provides the knowledge of solar terrestrial phenomena and also provides warnings of solar wind occurrences that may impair long-range communication, high-altitude manned operations, or disrupt satellite operations.
- The Search and Rescue (SAR) instruments are part of the international COSPAS-SARSAT system designed to detect and locate Emergency Locator Transmitters (ELTs), Emergency Position-Indicating Radio Beacons (EPIRBs), and Personal Locator Beacons (PLBs) operating at 121.5, 243, and 406 MHz. All spacecraft since NOAA-15 carry two instruments to detect these emergency beacons; the Search and Rescue Repeater (SARR) provided by Canada, and the Search and Rescue Processor (SARP-2) provided by France.
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- The Solar Backscatter Ultraviolet Spectral Radiometer (SBUV) is used to measure solar irradiance (backscattered solar energy), total ozone concentrations, and the vertical ozone profile in the atmosphere.



## **NOAA-16**

NOAA-16 was launched on September 21, 2000. On August 30, 2005, it was designated a secondary afternoon spacecraft. On November 13, 2000 the VHF transmitter (VTX) failed which does not allow the broadcast of Automatic Picture Transmission (APT). Data Recorder DTR#5 failed February 2, 2000 and is no longer used due to a failure within its electronics. The SARR 243MHz signal failed on November 13, 2001. Since September 17, 2003, the AVHRR scan motor performance has changed causing periodic current surges and loss of sync. During periods of high scan motor current the imagery is degraded.

## **NOAA-15**

NOAA-15 was launched on May 13, 1998 and became operational on July 1998. As of October 15, 2003, NOAA-15 was designated as a secondary spacecraft. As such, it operates in an orbit with a 7:30 am descending node (morning orbit) and utilizes the same set of instruments as NOAA-16 except the SBUV. NOAA-15 has anomalous instrument behavior in the HIRS and AVHRR and the on-orbit failure of three high gain downlink antennas. The AVHRR is re-phased once a day to assist the scan motor to maintain synchronization. The SARR 243MHz signal is inoperative. On AMSU-A1, channels 11 and 14 are inoperative.

## **Standby Spacecraft**

NOAA-14 was launched in December 1994. On July 21, 2005, the AVHRR began scanning again after a year. It is the last spacecraft with functional Microwave Sounding Unit (MSU) and Stratospheric Sounding Unit (SSU).

NOAA-12 was launched in May 1991. Its AVHRR could be used to satisfy morning mission user data requirements.

NOAA-11 was launched in September 1988. As of May 2003, it has been designated non-operational spacecraft. This spacecraft was de-commissioned in June 2004.

## **1.2 Defense Meteorological Satellite Program (DMSP)**

Over the last four years, NOAA and the US Air Force successfully completed the safe and efficient convergence of the five Defense Meteorological Satellite Program (DMSP) military satellites into the NOAA meteorological constellation. Initiated via Presidential Decision Directive in 1994, this convergence capitalizes on many of the shared resources and mission requirements of the civilian and military polar-orbiting spacecraft. The transfer of operations convergence is an interim step toward development of a single, integrated environmental satellite system designed to meet civilian and military needs. The first satellite in the new system will be available for launch in 2012.

Similar to the civilian POES program, the DMSP program designs, launches, and maintains several near polar orbiting, sun synchronous satellites monitoring the



meteorological, oceanographic, and solar-terrestrial physics environments. The visible and infrared sensors collect images of global cloud distribution across a 3,000-kilometer swath during both daytime and nighttime conditions. The current DMSP constellation consists of two primary, two secondary, and one backup operational spacecraft.

## 2. Geostationary Meteorological Satellite Systems

The current Geostationary Operational Environmental Satellites (GOES) are three-axis stabilized spacecraft in geosynchronous orbits. The current primary satellites, GOES-12 and GOES-11, are stationed over the east and west coasts of the United States. These satellites are used to provide simultaneous images and soundings of the Western Hemisphere. GOES-10 is moving towards 60 deg W to support coverage of South America. GOES-9 is in standby mode at 200 W GOES-8 was deorbited on May 5, 2004. GOES-3 and GOES-7, spin-stabilized satellites from the previous GOES series, continue a track record of more than 55 years of combined service via continued support of non-NOAA users in a data relay mode (non-imaging).

The primary instrument payload for the current series of GOES spacecraft consists of:

- The Imager, a multi-channel instrument designed to sense radiant and solar reflected energy. The GOES-12 spacecraft has a new 13.3 micron channel, which replaces the 12 micron channel on earlier satellites. It will provide data for upper level wind predictions.
- The Sounder, which provides data for atmospheric temperature and moisture profiles, surface and cloud top temperature and ozone distributions.

The Imager and Sounder both have the capability to sense stars during non-imaging times for use in Image Navigation and Registration (INR). In addition, the spacecraft can apply compensation signals to the instrument servo motors to compensate for repeatable long-term orbit and attitude effects.

The GOES spacecraft also have Space Environmental Monitor (SEM) systems to measure magnetic fields, solar x-ray flux and high energy electrons, protons and alpha particles. GOES-12 has the Solar X-Ray Imager (SXI) instrument provides real-time images (once per minute) of the sun in the X-Ray band.

A data collection system on the GOES spacecraft receives and relays environmental data sensed by widely dispersed surface platforms such as river and rain gauges, seismometers, tide gauges, buoys, ships and automatic weather stations. Platforms transmit sensor data to the satellite at regular or self-timed intervals, upon interrogation by the satellite, or in an emergency alarm mode whenever a sensor receives information exceeding a preset level.

### **GOES-13**

GOES-13 was successfully launched on May 24, 2006. The spacecraft is currently in post launch testing. After completion of testing in late December 2006, the spacecraft will be placed into storage at 105° W.



## **GOES-12**

GOES-12 was successfully launched on July 23, 2001. As of April 1, 2003, GOES-12 became the operational East Coast satellite at 75° W. On September 2, 2003, the SXI went into Safe Mode locking the filter wheel and turning off the High Voltage Power Supply (HVPS) and on November 11, 2003, the SXI pre-filter failed allowing unfiltered sun-light into the instrument. SXI filtered channels are unaffected. The SXI continues to experience problems with stray light. Currently the instrument is in safe mode.

## **GOES-11**

The GOES-11 is the operational West Coast satellite at 135 deg W. The spacecraft was successfully launched on May 3, 2000.

## **GOES-10**

GOES-10 is moving towards 60 deg W to provide additional coverage of South America. Shortly after launch in April 1997, GOES-10 suffered a near-fatal anomaly when its solar array stopped moving, either due to a gear train jam or due to an external jam. The anomaly was studied over a period of months, and it was decided to invert the satellite (180 degrees in relation to the Earth) and run the array drive in the reverse direction to track the sun. This operational strategy was coupled with extensive ground and spacecraft software modifications to allow the imagery to look "non-flipped" to the users. GOES-10 performed its last North/South (yearly inclination change) maneuver in June 2005.

## **GOES-9**

GOES-9 was launched in May 1995. Currently, GOES-9 has been located at 200 W in standby mode. On January 1, 2003, the tachometer output from one of the two primary momentum wheels (Momentum Wheel #2) was lost. As a result, the AOCE lost the ability to control the wheel, and on April 14, 2003, a redundant reaction wheel was activated.

## **GOES-7 and GOES-3**

Launched in February of 1987, GOES-7 completed almost nine years of operational service with a final operational image on January 11, 1996 (after GOES-9 was declared fully operational). GOES-7 was last called into service to support the relay of operational weather data during the GOES-8 wheel tachometer failure in January 1997. GOES-7 is currently located over the Pacific to support data relay requirements for the University of Hawaii's Pan-Pacific Educational and Cultural Satellite (PEACESAT) Program as a replacement to GOES-2.

Due to a highly inclined geostationary orbit (approximately 13.5 degrees), GOES-3 is currently able to support data relay requirements to the South Pole Station for the National Science Foundation (NSF). GOES-3 no longer has any remaining imaging capabilities.