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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 four geostationary and eleven 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 August 31, 2011.

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 one primary, three backups, and one secondary spacecraft. These spacecraft are in circular orbits inclined at approximately 98 degrees (retrograde). As of May 21, 2007, NOAA declared EUMETSAT's METOP-A as NOAA's mid-morning primary operational spacecraft. NOAA's primary afternoon operational spacecraft, NOAA-19, was launched on February 6, 2009 and declared operational June 2, 2009. Three backup spacecraft, NOAA-18, NOAA-17 and NOAA-15 provide additional payload operational data. NOAA-16 is a secondary afternoon spacecraft supporting additional user data requirements. NOAA-14 and NOAA-12 were decommissioned on May 23, 2007 and August 10, 2007, respectively.

NOAA-19

NOAA-19 was launched February 6, 2009. Declared operational on June 2, 2009, NOAA-19 replaced NOAA-18 as the Primary afternoon spacecraft for IJPS. NOAA-19 operates in an orbit with a 1:32 PM ascending node (afternoon orbit) at an altitude of 870km, functioning nominally. In December 2009, the Microwave Humidity Sounder (MHS) Channels H3/H4 increased NEdT causing impacts to products. Channel H4 has stabilized and corrections are applied in the ground processing. However, Channel H3 remains out of specification.

The NOAA-19, or afternoon primary, instrument payload includes:

- * The Advanced Very High Resolution Radiometer (AVHRR/3), a six channel imaging radiometer which detects energy in the visible and 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.
- * 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 data is



used to provide precipitation and surface measurements including snow cover and sea ice concentration.

- 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 provided qualitative estimates of the precipitation rate.
- X The Solar Backscatter Ultraviolet Spectral Radiometer (SBUV/2) is used to measure solar irradiance (backscattered solar energy), total ozone concentrations, and the vertical ozone profile in the atmosphere.
- * 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 Advanced Data Collection System (ADCS) 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 ADCS 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. NOAA-19's ADCS adds additional functionality to the DCS employed by older NOAA spacecraft: the ability to downlink messages to environmental data collection platforms (mostly to modify performance) and the ability to receive, process, and command to the next generation of data collection platforms currently in development.
- * 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-3) provided by France. Starting in February 2009, the 121.5MHz and 243MHz beacons are no longer supported by COSPAS/SARSAT and have not been activated on NOAA-19.

NOAA-18

NOAA-18 was launched on May 20, 2005. As of August 30, 2005, NOAA-18 was designated operational. NOAA-18 operates in an orbit with a 1:22 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. On May 22, 2008, NOAA-18's SBUV chopper motor seized, rendering the SBUV unit inoperable. The instrument was recovered on August 12, 2008. New flight software macros were loaded to the spacecraft to assist in the recovery if the motor seizes again. Currently the SBUV is operating nominally. On June 7, 2009, MIMU2 failed on NOAA-18. The spacecraft is now operating on its redundant unit.

NOAA-17

NOAA-17 was launched on June 24, 2002 and became operational on October 15, 2002. With the successful launch and checkout of METOP-A, NOAA-17 now supports the mid-morning mission as a backup spacecraft, but drifted with to 20:01 ascending node (morning orbit). On February 15, 2003, DTR5 failed to operate and on April 28, 2003, STX3 power degraded to 2 watts, dropping further to an inoperable .2W on February 14, 2008. On March 2, 2008, STX1 output power dropped to 2.29W, but is still operable. On October 28, 2003, the AMSU-A1 scan motor failed thus the instrument no longer provides any data. In January 2010, the AVHRR started to show increase motor current and degradation in imagery. The scan motor ceased to operate on October 15, 2010. As of December 2009 AMSU-B Channels 18-20 are no longer functioning.

The NOAA-17 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.
- * 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-16

NOAA-16 was launched on September 21, 2000. On August 30, 2005, it was designated a secondary afternoon spacecraft with a 19:44 PM ascending node (afternoon orbit). 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 and the SARR121.5MHz Receiver was turned off on July 29, 2008 per USMCC/SARSAT request. 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. On September 28, 2001, STX3 output power degraded from 9W to 1W and was deemed inoperable for many years. After testing in the early fall of 2007, STX3 was deemed usable for low rate data on October 2, 2007.

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, but drifted with a 16:37 PM ascending node (morning orbit) and utilizes the same set of instruments as NOAA-16 except the SBUV. NOAA-15 HIRS has anomalous instrument behavior, of which Filter wheel finally stalled on June 6, 2009, and also three high gain downlink antennas failed on-orbit. The AVHRR is re-phased once a day to assist the scan motor to maintain synchronization. The SARR 243MHz signal is inoperative and the SARR 121MHz Receiver was decommissioned by COSPAS/SARSAT international mandate on February 1, 2009. On AMSU-A1, channels 11 and 14 are inoperative. On March 11, 2010 spacecraft was placed in reduced gyro attitude control mode due to failures



within the Inertial Measurement Unit (IMU). Due to the failure there are navigation errors that seen in real-time products. As of September 14, AMSU-B Channels 18-20 are no longer functioning, and finally the scan motor has ceased to rotate on March 28, 2011.

Decommissioned Spacecraft

NOAA-14 was launched in December 1994. This spacecraft was decommissioned on May 23, 2007.

NOAA-12 was launched in May 1991. This spacecraft was decommissioned on August 10, 2007.

1.2 Defense Meteorological Satellite Program (DMSP)

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 two 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-13 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-15 is located at 89.5 deg W supporting NWS Space Weather Prediction Center with the XRS and SXI instruments. GOES-12 was re-located at 60 deg W to support coverage of South America in May 2010. GOES-14 is in storage mode at 105 deg W. 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-13 spacecraft has 5 channels: one visible and four IR channels. The 13.3 micron IR channel is 8 km resolution and the other three IR have 4 km resolution.

The Sounder, which provides data for atmospheric temperature and moisture profiles, surface and cloud top temperature and ozone distributions.

The newer GOES NOP spacecraft use star trackers for navigation for improved Image Navigation and Registration (INR). 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-13, GOES-14 and GOES-15 have the Solar X-Ray Imager (SXI) instrument to provide 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-15

GOES-15 was successfully launched at 6:57PM EST on March 4, 2010. GOES-15 has completed Post Launch Testing (PLT) and NASA has transferred the satellite to NOAA on September 1, 2010. GOES-15 is currently operating at 89.5 deg W to support NWS Space Weather Prediction Center. Only the instruments XRS and SXI are providing data. GOES-15 is planned to replace GOES-11 as GOES-West in December 2011.



GOES-14

GOES-14 was successfully launched at 6:51PM EDT on June 27, 2009. GOES-14 is currently in storage mode at 105 deg W.

GOES-13

GOES-13 was successfully launched on May 24, 2006. GOES-13 was moved to 75 deg W in April 2010 to become GOES East. The XRS does not provide any solar flare information. The SXI has detector damage due to solar flare in December 5, 2006.

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. SXI Imaging has been indefinitely suspended as of 4/12/2007. GOES-12 was relocated to 60 W deg in May 2010 to support South America.

GOES-11

The GOES-11 is the operational West Coast satellite at 135 deg W. The spacecraft was successfully launched on May 3, 2000. The X-Ray Positioner failed Feb. 2, 2008 which no longer allows the XRS to be pointed precisely at the Sun.

GOES-10

GOES-10 was decommissioned on December 2, 2010.

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.