CGMS-XXVII
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Agenda Item: B.1 & B.2
USA-WP-02 & 03

CGMS - Satellite Constellation Status

WP-02- Polar Operational Environmental Satellite (POES)

WP-03 Geostationary Meteorological Satellite Systems

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The National Oceanic and Atmospheric Administration (NOAA) manages a constellation of six geostationary and ten polar orbiting meteorological spacecraft, including five 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. Upcoming launches include a new military polar-orbiting spacecraft in October of 1999, a geostationary satellite in late fall or early spring of next year and a new polar orbiting civilian satellite in the spring of 2000

B.1 Status of USA Polar Orbiting Meteorological Satellite Systems

Polar Operational Environmental Satellite (POES)

The POES spacecraft constellation includes two primary, two secondary and one standby spacecraft. These spacecraft are in circular orbits inclined at approximately 98 degrees (retrograde). The primary operational spacecraft, NOAA-14 and NOAA-15, are in sun-synchronous afternoon and morning orbits, respectively. Two secondary spacecraft, NOAA-11 and NOAA-12, provide additional payload operational data, while the standby spacecraft, NOAA-10, supports minimal SAR functions and is only contacted once a week.

NOAA-15

NOAA-15, the newest POES spacecraft, was launched on May 13, 1998. After a 60-day Orbital Verification period was completed, NOAA-15 was designated as the operational replacement for NOAA-12. As such, it operates in an orbit with a 7:30 am descending node (morning orbit) and utilizes a similar set of instruments as NOAA-12.

The NOAA-15, 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. The NOAA-15 spacecraft carries 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.

NOAA-14

NOAA-14, which was launched in December 1994, is the operational afternoon (ascending node) spacecraft. One of the two on-board processors (OBP) is unusable due to the malfunction of an associated command demodulator.

Except for the failure of the on-board Search and Rescue Processor (SARP), all instrument subsystems are currently providing usable data. On two different instruments, the Microwave Sounding Unit (MSU) and the Solar Backscatter Ultraviolet Spectral Radiometer (SBUV), drive motors for different movable assemblies have been observed to seize (the MSU scanner and the SBUV grating drive). As a result, command sequences have been coded into the on-board software that shuts off the appropriate instrument drive when elevated temperatures are observed that would be indicative of drive seizure.

The afternoon instrument payload on NOAA-14 is similar to the functionality of the NOAA-15 instruments except for two important distinctions.

- NOAA-14 uses the Microwave Sounding Unit (MSU) and Stratospheric Sounding Unit (SSU) to support atmospheric sounding data collection. These instruments are the predecessors to the two Advanced Microwave Sounding Units (AMSU-A and AMSU-B) on the NOAA-15 (and later) spacecraft.

- The major addition to the afternoon suite of instruments is the addition of the Solar Backscatter Ultraviolet Spectral Radiometer (SBUV). The SBUV is used to measure solar irradiance (backscattered solar energy), total ozone concentrations, and the vertical ozone profile in the atmosphere.

Backup Spacecraft

NOAA-11, launched in September 1988, and NOAA-12, launched in May 1991, are the backup afternoon and morning spacecraft, respectively. Both spacecraft actively support data products or services in a backup role. Some of the supported products or services include:

- NOAA-11 SBUV data

- NOAA-11 HIRS data
- NOAA-12 high resolution real-time picture transmission
- Search and rescue service (both spacecraft)

NOAA-10, launched in September 1986, is on Standby status and is only contacted once per week. Even in this role, NOAA-10 still serves as a Search and Rescue signal repeater function to the SAR community.

Defense Meteorological Satellite Program (DMSP)

Over the two 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 July 2007.

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. The next DMSP spacecraft is slated for launch sometime in October of 1999.

B.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-8 and GOES-10, 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. In the past year, GOES-10, launched in 1997, was transitioned out of an on-orbit storage mode and was brought into primary status as a replacement to GOES-9. GOES-9, which suffered from a lubricant starvation condition of its momentum wheels, was subsequently transitioned to a passive, spin-stabilized storage mode. GOES-2, 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, which is a multichannel instrument designed to sense radiant and solar reflected energy.

- 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. Both GOES-8 and GOES-9 SEM subsystems are operating nominally.

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-8

GOES-8, launched in April 1994, is stationed over the East Coast of the United States at 75□W. The first of the series, GOES-8 retains the ability to provide the full range of products, although with some loss of redundancy of backup systems.

Both of the GOES-8 primary instruments are providing operational data, however one of the servo motor windings in the Sounder instrument failed in August 1994. The winding failure is believed to be a result of stresses induced by a combination of motor material incompatibilities and elevated temperatures, which occur primarily at spacecraft midnight. Data products are

unaffected due to the use of a redundant coil, but due to a similar failure on GOES-9, the servo motors have been redesigned for GOES-10.

The GOES-8 spacecraft bus continues to operate nominally with some loss of redundancy. Due to the location and mechanical mounting of the Attitude and Orbit Control Electronics (AOCE), the two AOCEs are susceptible to electrostatic discharge (ESD) events at specific times each year. Since launch, six ESD events have occurred on GOES-8. These events usually manifest themselves as soft (i.e. correctable) upsets to RAM locations, but on one occasion in April of 1996, a hard error occurred where the ability to address a quarter of the RAM locations on the primary AOCE was lost. Operations have been nominal on the backup AOCE since the anomaly. As a result of some of the earlier ESD events, some design modifications were made to GOES-9 before launch. No ESD events have been experienced on GOES-9 or GOES-10 to-date.

On January 9, 1997, the tachometer output from one of the two primary momentum wheels (Momentum Wheel #1) was lost. As a result, the AOCE lost the ability to control the wheel, and on January 10, a redundant reaction wheel was activated. Since that time, the spacecraft has operated nominally in the backup control mode and investigations are underway to recover some limited usage of Momentum Wheel #1.

GOES-10

GOES-10 is the operational West Coast satellite at 135□ W. Shortly after launch in April 1997, GOES-10 suffered a near-fatal anomaly when it's solar array stopped moving, either due to a gear train jam or due to an external stoppage. Studied over a period of months, it was decided to flip 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-9

Launched in May 1995, GOES-9 is now in a Z-axis Precession (ZAP) mode, a spin-stabilized storage mode that minimizes use of life-limited spacecraft components and requires little operator intervention. In the summer of 1998, GOES-9's momentum wheels started to show signs of significant lubrication starvation. GOES-9 was put into storage mode in anticipation of imminent wheel failure. Currently located at 105 degrees W, GOES-9 is can be called up to replace either GOES-8 or GOES-10 in the event of a spacecraft failure.

GOES-7, GOES-3 and GOES-2

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 being moved west 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 12□), GOES-3 is currently able to support data relay requirements to the South Pole Station for the National Science Foundation (NSF). As mentioned above, GOES-2 is currently supporting data relay requirements for the

University of Hawaii's PEACESAT Program. Neither GOES-2 nor GOES-3 have any remaining imaging capabilities.

GOES-L

To ensure a full two spacecraft operational configuration, GOES-L will be launched in by late fall of 1999 or early spring, 2000. GOES-L will join GOES-9 in a spin-stabilized storage mode and will be called up to replace either GOES-8 or GOES-10, as the primary stored spacecraft.