Overview of the GOES Mission

Goals of the Mission

The goals of the Geostationary Operational Environmental Satellite (GOES) system program are to:

- Maintain reliable operational, environmental, and storm warning systems to protect life and property
- Monitor the earth's surface and space environmental conditions
- Introduce improved atmospheric and oceanic observations and data dissemination capabilities
- Develop and provide new and improved applications and products for a wide range of federal agencies, state and local governments, and private users

To address these goals, the National Weather Service (NWS) and the National Environmental Satellite Data and Information Service (NESDIS) of the Department of Commerce established mission requirements for the 1990s that are the bases for design of the GOES I-M system and its capabilities. The GOES system thus functions to accomplish an environmental mission to service the needs of operational meteorological, space environmental, and research users.

The GOES System

To accomplish this mission, the GOES I-M series of spacecraft perform three major functions:

- ***Environmental Sensing***: Acquisition, processing, and dissemination of imaging and sounding data independent of imaging data processes and the *(in-situ)* space environment monitoring data, and measurement of the near-earth space "weather."
- ***Data Collection***: Interrogate and receive data from earth surface-based data collection platforms (DCPs) and relay to the National Oceanic and Atmospheric Administration (NOAA) command and data acquisition stations.
- ***Data Broadcast***: Continuous relay of weather facsimile and other meteorological data to small users, independent of all other system functions; relay of distress signals from aircraft or marine vessels to the search and rescue ground station of the search and rescue satellite-aided tracking system.

Each mission function is supported or performed by components of the GOES I-M payloads:

Environmental sensing:

- Five-channel Imager
- Nineteen-channel Sounder
- Space environment monitor (SEM)
  - Energetic particles sensor (EPS)
  - High energy proton and alpha particle detector (HEPAD)
  - X-ray sensor (XRS)
  - Magnetometers

Data collection:

- Data collection system (DCS)

Data broadcast:

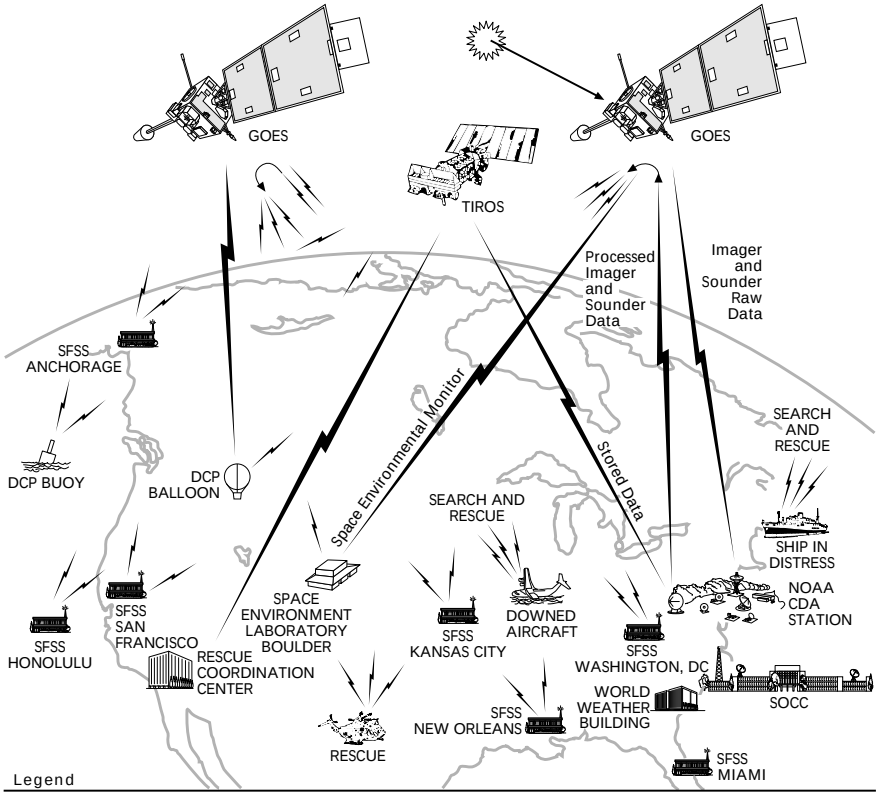
- Processed data relay (PDR) and weather facsimile (WEFAX) transponders
- Search and rescue (SAR)
- Sensor data and multiuse data link (MDL) transmitters

The remote sensing function is carried out by the 5-channel Imager and 19-channel Sounder, both of improved spatial and spectral resolution, and *in-situ* sensing by a SEM covering an extensive range of energy levels. The acquisition of sensed data and its handling, processing, and final distribution are performed in real-time to meet observation time and timeliness requirements, including revisit cycles. Remotely sensed data are obtained over a wide range of areas of the western hemisphere, encompassing the earth's disk, selected sectors, and small areas. Area coverage also includes the visibility needed to relay signals and data from ground transmitters and platforms to central stations and end users.

The Mission Capable Space Segment

The GOES I-M series of spacecraft are the prime observational platforms for covering dynamic weather events and the near-earth space environment for the 1990s and into the 21st century. These advanced spacecraft enhance the capability of the GOES system to continuously observe and measure meteorological phenomena in real-time, providing the meteorological community and atmospheric scientists of the western hemisphere with greatly improved observational and measurement data. These enhanced operational services improve support for short-term weather forecasting and space environment monitoring as well as atmospheric sciences research and development for numerical weather prediction models, meteorological phenomena, and environmental sensor design.

The Weather Watch System of the 1990s



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The Observational Platform

The advanced GOES I-M spacecraft three-axis, body-stabilized design enables the sensors to "stare" at the earth and thus more frequently image clouds, monitor the earth's surface temperature and water vapor fields, and sound the earth's atmosphere for its vertical thermal and vapor structures. Thus the evolution of atmospheric phenomena can be followed, ensuring real-time coverage of short-lived, dynamic events, especially severe local storms and tropical cyclones, two meteorological events that directly affect public safety, protection of property, and, ultimately, economic health and development.

Innovative features incorporated in the GOES I-M spacecraft enable high volume, high quality data to be generated for the weather community. Two important capabilities are flexible scan control that allows small area coverage for improved short-term weather forecasts over local areas, and simultaneous,

independent imaging and sounding. Precision on-orbit stationkeeping, coupled with three-axis stabilization, provides a steady observational platform for the mission sensors, greatly increasing earth-referenced data location and measurement accuracy. To maintain location accuracy, an innovative image navigation and registration (INR) methodology is employed that uses star sensing via the primary instruments. The INR subsystem provides daily imaging and sounding data on a precisely located, fixed earth coordinate grid without ground interpolation.

The Imager

The Imager is a multispectral, earth-scanning instrument capable of sweeping simultaneously one visible and four infrared channels in a north-to-south swath across an east-to-west path, and providing full earth imagery, sector imagery containing edges of earth's disk, and area scans of local regions. Besides simultaneous imaging, it features higher infrared spatial (4 kilometers, 2.5 statute miles) and spectral resolution in the surface and cloud detection channels, and increased sensitivity, all of which enhance quantitative estimates of surface temperature and low-level moisture and monitoring of convective intensity. Imaging over five channels significantly improves cloud and water vapor measurements and produces visual and infrared images of the earth's surface, oceans, cloud cover, and severe storm developments. Cloud imagery is available to users in mapped format (available for each channel) as well as the familiar GOES projection sectors. Two composite images, visible-infrared and infrared-water vapor, are also produced.

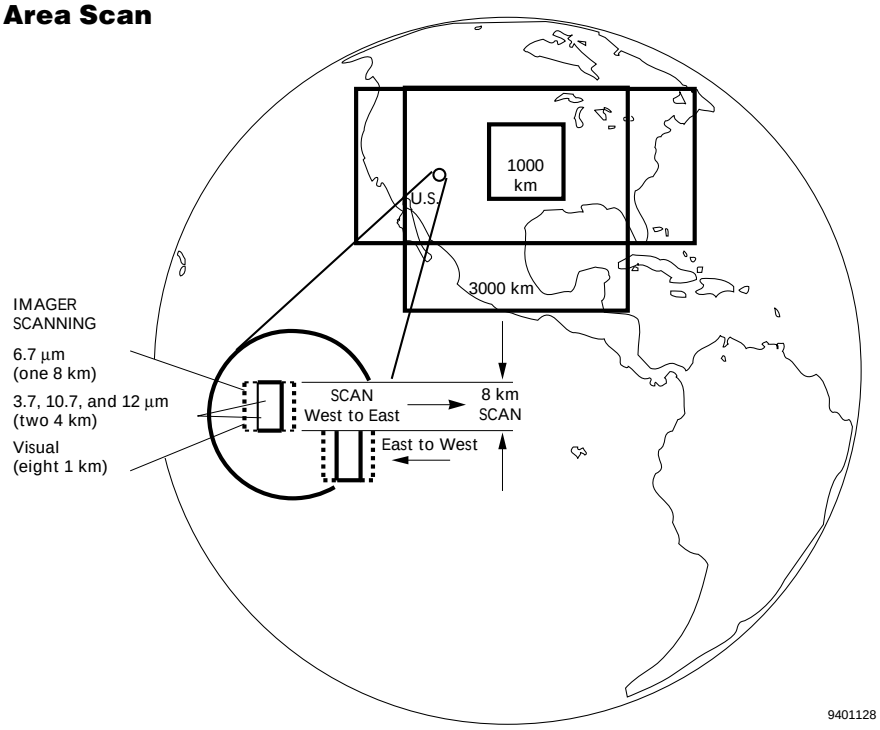
The Sounder

The GOES I-M Sounder features more spectral channels, higher spatial resolution (8 kilometers, 5 statute miles), and increased sensitivity for high quality soundings than are currently available. It is capable of stepping 1 visible and 18 infrared channels in a north-to-south swath across an east-to-west path. The Sounder and Imager both provide full earth imagery, sector imagery containing the edges of earth's disk, and area scans of local regions. Nineteen spectral bands (seven longwave, five midwave, six shortwave, and one visible) yield the prime sounding products of vertical temperature profiles, vertical moisture profiles, layer mean temperature, layer mean moisture, total precipitable water, and the lifted index (a measure of stability). These products are used to augment data from the Imager to provide information on atmospheric temperature and moisture profiles, surface and cloud top temperatures, and the distribution of atmospheric ozone.

Flexible Scan Control

Both Imager and Sounder employ a servo-driven, two-axis gimballed mirror system in conjunction with a 31.1-centimeter (12.2-inch) aperture Cassegrain telescope. As separate sensors, they allow simultaneous and independent surface imaging and atmospheric sounding. Each has flexible scan control, enabling coverage of small areas as well as hemispheric (North and South America) and global scenes (earth's full disk), and close-up, continuous observations of severe storms and of dynamic, short-lived weather phenomena.

Area Scan



A priority scan feature allows improved scheduling of small area and mesoscale scans for short range forecasts and storm warnings. Imager large area scans of 3000 by 3000 kilometers (1864 by 1864 statute miles) are accomplished in three minutes and small area scans of 1000 by 1000 kilometers (621 by 621 statute miles) can be made in 41 seconds. A 3000- by 3000-kilometer area can be sounded in 43 minutes, and full earth can be imaged in 26 minutes.

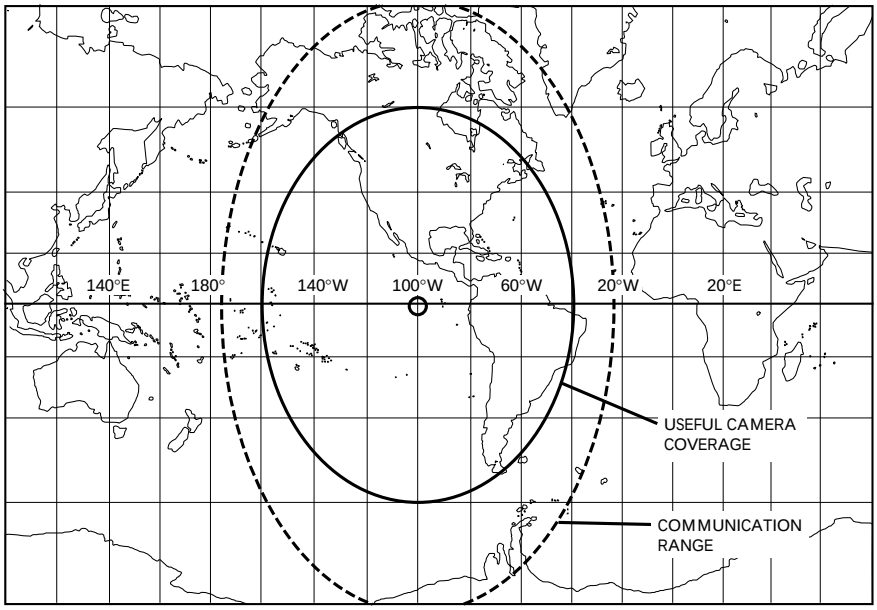
Space Environment Monitoring

The SEM instruments survey the sun, measuring *in situ* its effect on the near-earth solar-terrestrial electromagnetic environment. Changes in this "space weather" can affect operational reliability of ionospheric radio; over-the-horizon radar; electric power transmission; and most importantly, human crews of high altitude aircraft, the Space Shuttle, or a Space Station.

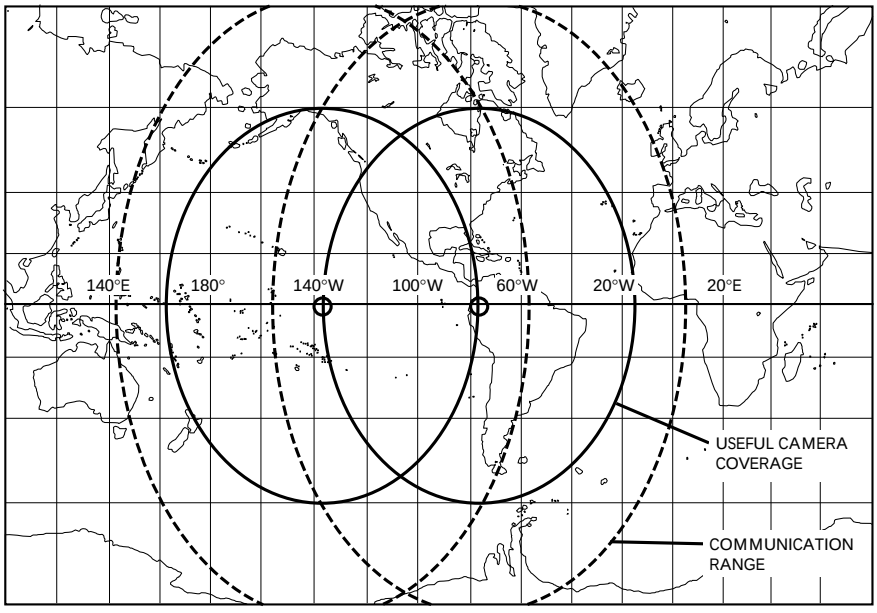
The XRS monitors the sun's total X-ray activity. The EPS and HEPAD detect energetic electron and proton radiation trapped by the earth's magnetic field as well as direct solar protons, alpha particles and cosmic rays. The magnetometer measures three components of earth's magnetic field in the vicinity of the spacecraft and monitors variations caused by ionospheric and magnetospheric current flows.

GOES Geographic Coverage

One Satellite



Two Satellites



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3Data Broadcast

GOES also enhances services for receiving meteorological data from earth-based data collection platforms and relaying the data to end-users. A continuous, dedicated search and rescue transponder on board provides for immediate detection of distress signals from downed aircraft or marine vessels and relays them to ground terminals to speed help to people in need. Increased communications capacity permits transmission of processed weather data and weather facsimile for small local user terminals in the western hemisphere.

Geographic Coverage

The GOES spacecraft, on-station 35,790 kilometers (22,240 statute miles) above the equator and stationary relative to the earth's surface, can view the contiguous 48 states and major portions of the central and eastern Pacific Ocean and the central and western Atlantic Ocean areas. Pacific coverage includes the Hawaiian Islands and Gulf of Alaska, the latter known to weather forecasters as "the birthplace of North American weather systems." Because the Atlantic and Pacific basins strongly influence the weather affecting the United States, coverage is provided by two GOES spacecraft, one at 75° west longitude, *GOES East*, and the other at 135° west longitude, *GOES West*.

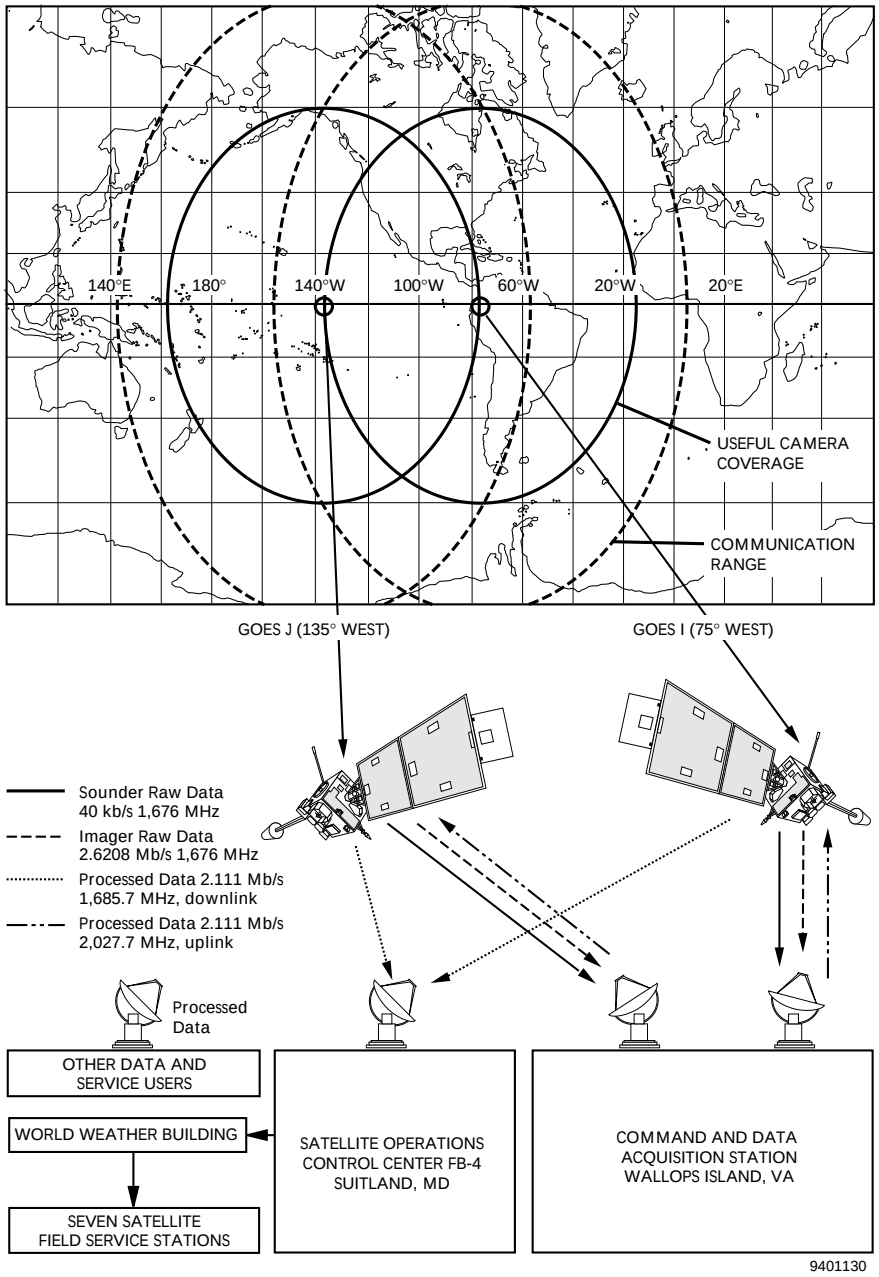
The combined footprint (radiometric coverage and communications range) of the two spacecraft encompasses earth's full disk about the meridian approximately in the center of the continental United States. Circles of observational limits centered at a spacecraft's suborbital point extend to about 60° north/south latitudes. The radiometric footprints are determined by the limit from the suborbital point, beyond which interpretation of cloud data becomes unreliable.

At least one GOES spacecraft is always within line-of-sight view of earth-based terminals and stations. The Command and Data Acquisition (CDA) Station is in line-of-sight to both spacecraft so that it can uplink commands and receive downlinked data from each simultaneously. Data collection platforms within the coverage area of a spacecraft can transmit their surface-based sensed data to the CDA Station via the onboard data collection subsystem. Similarly, ground terminals can receive processed environmental data and WEFAX transmissions.

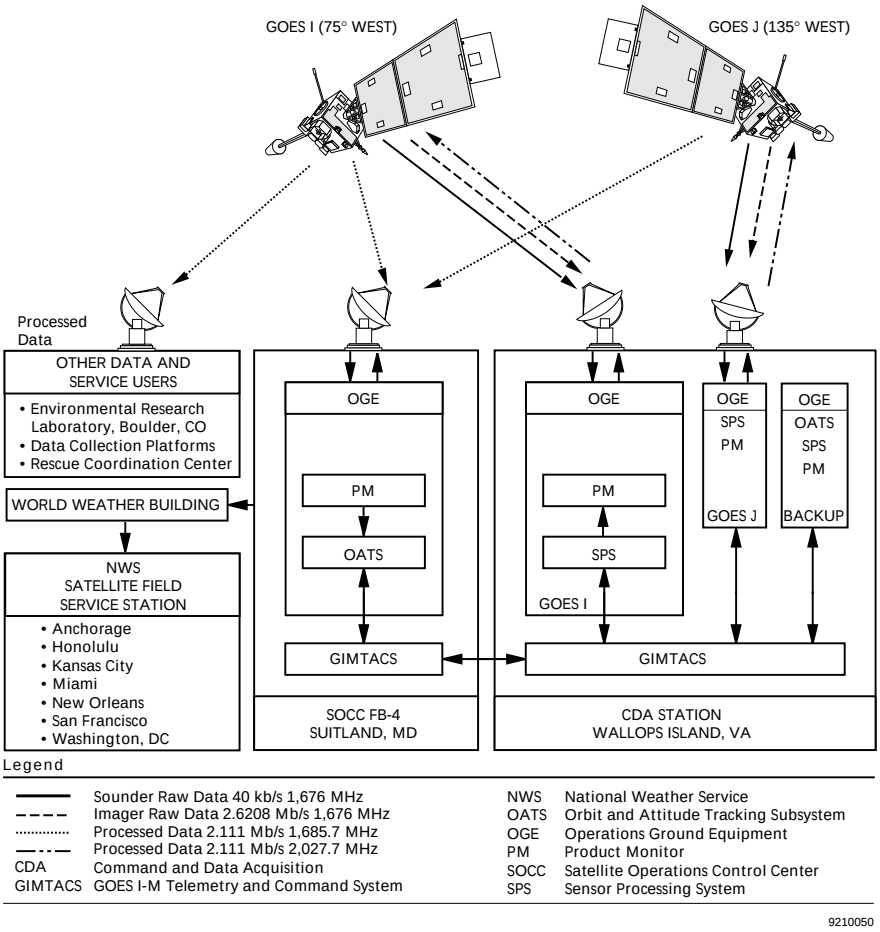
Ground Segment Support

Raw Imager and Sounder data received at the NOAA CDA Station are processed in the operations ground equipment (OGE) with other data to provide highly accurate, earth-located, calibrated imagery and sounding data in near real-time for retransmission via GOES spacecraft to primary end users, typically the seven NWS Field Service Stations located throughout the United States. Operational management and planning are performed at the Satellite Operations Control Center (SOCC), where all elements of the system are monitored, evaluated, scheduled, and commanded.

GOES System Functional Diagram



Data Transmissions



Network Architecture

The communications links, ground support equipment connectivity, and data transmission paths complete the interfaces among GOES I-M-specific and existing equipment. This network, transparent to current users, routes broadcast and mission data. The Imager and Sounder output serial bit streams are transmitted on the S-band carrier wave by the sensor data transmitter. The GOES spacecraft signal is received at the CDA Station where it is demodulated and processed by the OGE; the new uplink signal, containing calibrated, earth-located data, is uplinked from the CDA Station to the spacecraft, received by the S-band receiver, and converted to the appropriate transmit frequency. Before being multiplexed and retransmitted to user stations by the S-band transmit antenna, the signal is prefiltered to separate it from other uplinked signals.

GOES Variable Data Format

The GOES I-M variable (GVAR) data transmission format is primarily used to transmit Imager and Sounder meteorological data. It also includes telemetry, calibration data, text messages, spacecraft navigation data, and auxiliary products. The GVAR format originated in the operational visible infrared spin scan radiometer, atmospheric sounder (VAS) mode AAA of the early spin-stabilized GOES spacecraft. The AAA format consists of a repeating sequence of 12 fixed-length, equal size blocks whose transmission is synchronized with spacecraft spin rate (that is, one complete 12-block sequence for each rotation).

The range and flexibility of satellite operations have increased with the advent of three-axis stabilized GOES I-M spacecraft employing two independent instruments, each with a scanning mirror having 2 degrees of freedom. The use of a fixed-length transmission format would have imposed operational limits on the capabilities of the I-M spacecraft. To fully use these new capabilities, the GVAR format was developed, supporting variable length scan lines, while retaining as much commonality as possible with AAA reception equipment.

Operations Ground Equipment

The OGE consists of components located at the CDA Station, Wallops Island, Virginia, and the SOCC at Suitland, Maryland. The OGE receives input streams of raw Imager and Sounder data and MDL data from the spacecraft. Primary outputs are PDRs of those data streams in GVAR format. One GVAR-formatted output data stream is generated for each spacecraft downlink data stream. The GVAR data stream is transmitted to its corresponding GOES spacecraft for relay to primary system users, as well as back to the CDA Station and SOCC for other internal OGE functions. Communications among the several elements of the OGE are via the GOES I-M telemetry and command system (GIMTACS).

Internal OGE uses of GVAR data are primarily for monitoring the quality of processed instrument data (CDA Station and SOCC), determining spacecraft range and extracting landmark images as part of orbit and attitude determination, and monitoring on-board computation of north/south and east/west image motion compensation to provide continuous scan frame registration. Also data from the MDL are received at the SOCC as an independent data link that, for GOES I, contains angular displacement sensor and digital integrating rate assembly data. These data are ingested and processed by the OGE and used for diagnosing dynamic interactions among the instruments and the spacecraft.

Communications Links

Description	Source	Uplink (MHz)	Downlink (MHz)	Destination
Command	CDA Station / DSN	2,034		Spacecraft
Telemetry (including SEM)	Spacecraft		1,694 / 2,209	CDA Station; DSN; Environmental Research Laboratory
WEFAX	CDA Station	2,033	1,691	Users; automatic picture transmission
Data Collection Platform Interrogate (DCPI)	CDA Station	2,034	468	DCP
Data Collection Platform Report (DCPR)	DCP	401	1,694	CDA Station; users
Search and Rescue (SAR)	Emergency Locator Transmitter (ELT)	406	1,544	Rescue coordination center
MDL (diagnostic data)	Spacecraft		1681.5	SOCC