1. Mission Overview

Mission Goals

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

- Maintain continuous, 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 National Oceanic and Atmospheric Administration (NOAA) established mission requirements for the 21^{st} century that are the basis for the design of the GOES N-P system and its capabilities. Figure 1-1 illustrates the GOES N satellite. The GOES system thus functions to accomplish an environmental mission serving the needs of operational meteorological, space environmental, and research users.

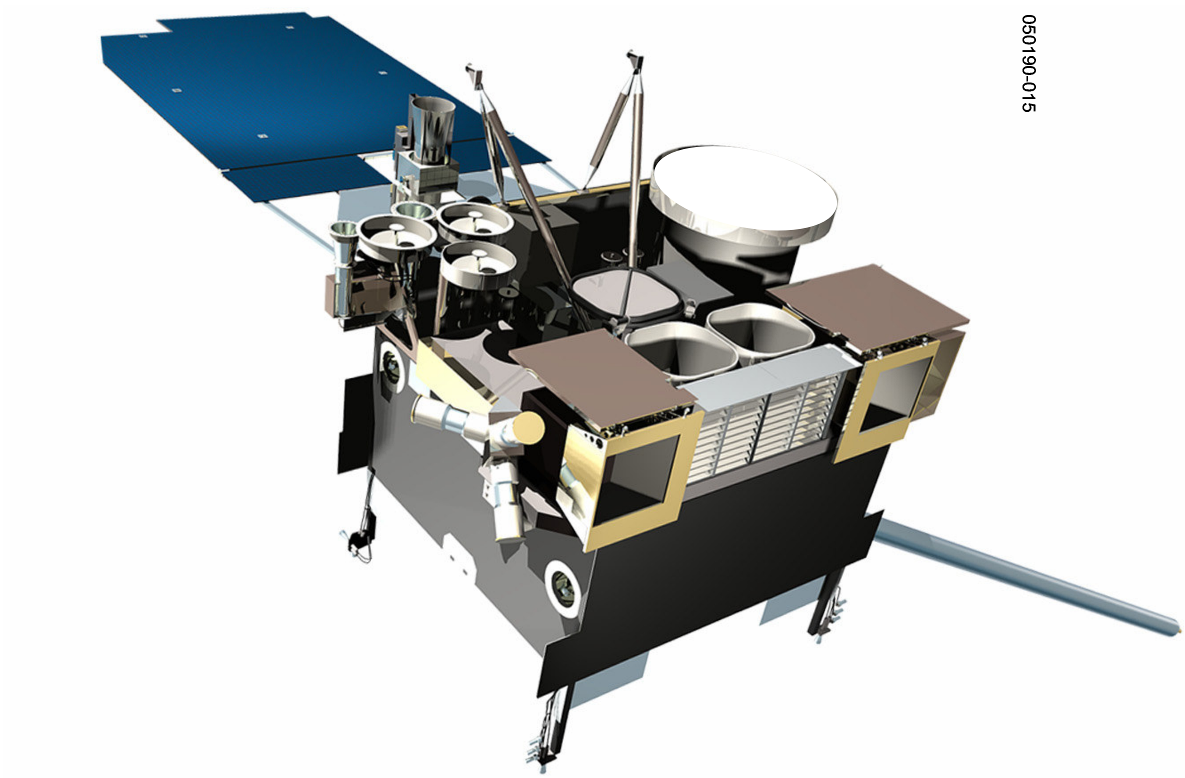


Figure 1-1. GOES N Satellite

GOES System

To accomplish the GOES mission, the GOES N-P series of spacecraft perform three major functions:

- ***Environmental sensing***—Acquisition, processing, and dissemination of imaging and sounding data, space environment monitoring data, and measurement of the near-earth space weather.
- ***Data collection***—Interrogation and reception of data from earth surface-based data collection platforms (DCPs) and relay of such data to the National Oceanic and Atmospheric Administration (NOAA) command and data acquisition stations.
- ***Data broadcast***—Processed data relay (PDR) of environmental sensor data. The relay of distress signals from aircraft or marine vessels to the search and rescue satellite-aided tracking system (SARSAT). The continuous relay of weather facsimile (WEFAX/LRIT) and other meteorological data to small users and the relay of emergency weather information to Civil Emergency Managers.

The three major mission functions are supported or performed by the following components of the GOES N-P payloads:

Environmental remote sensing

- Imager (earth atmosphere)
- Sounder (earth atmosphere)
- Space environment monitor (SEM)
  - Energetic particle sensor (EPS)
  - High energy proton and alpha particle detector (HEPAD)
  - X-ray sensor (XRS)
  - Extreme ultraviolet (EUV) instrument
  - Magnetometers
- Solar X-ray Imager (SXI)

Data collection

- Data collection system (DCS)
- Search and rescue (SAR)

Data broadcast

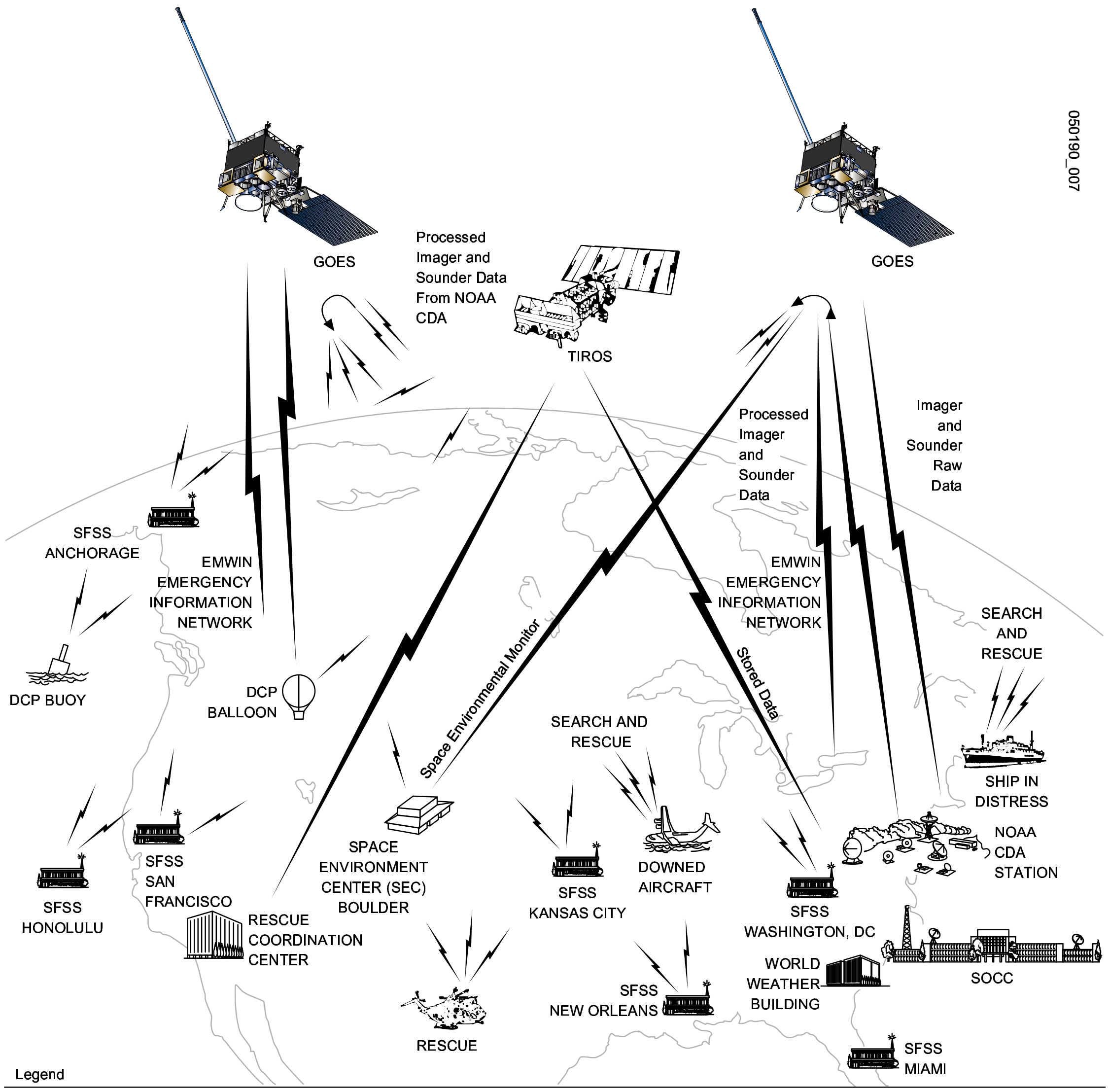
- Processed data relay (PDR), WEFAX/LRIT and emergency weather information (EMWIN) transponders
- Sensor data and multi use data link (MDL) transmitter

Telemetry and Command

- The T&C system controls and monitors the health and safety of the spacecraft (Details of the T&C system can be found in Section 9).

The environmental remote sensing function is executed by the 5-channel Imager and the 19-channel Sounder, both of which offer fine spatial and spectral resolution. *In-situ* sensing is performed by the SEM covering an extensive range of energies. Sensed data are acquired, processed, and distributed to users 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 ability needed to relay signals and data from ground transmitters and platforms to central stations and end users.

To accomplish the GOES system mission, space and ground segments are interconnected as shown in Figure 1-2.



CDA	Command and Data Acquisition	SFSS	Satellite Field Service Station
DCP	Data Collection Platform	SOCC	Satellite Operations Control Center
NOAA	National Oceanic and Atmospheric Administration		

Figure 1-2. 21st Century Weather Watch System

Space Segment

The GOES N-P series of spacecraft are the prime observational platforms for covering dynamic weather events and the near-earth space environment for 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.

Observational Platform

The advanced GOES N-P 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 water 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, These are meteorological events that directly affect public safety, protection of property, and, ultimately, economic health and development. Various design features of the GOES spacecraft enable high volume, high quality data to be generated for the weather community. There are two important capabilities. The first is flexible scan control—a capability that allows small area coverage for improved short-term weather forecasts over local areas—and simultaneous, independent imaging and sounding. The second is precision on-orbit stationkeeping, coupled with three-axis stabilization, ensures a steady observational platform for the mission sensors, greatly increasing earth-referenced data location and measurement accuracy. To maintain location accuracy, an image navigation and registration (INR) methodology is employed. This methodology uses geographic landmarks and star locations sensed, via the primary instrument, and ranging via the spacecraft communications system to maintain that location accuracy. The INR subsystem provides daily imaging and sounding data on a precisely located, fixed earth coordinate grid without ground interpolation. Key GOES N-P spacecraft parameters are given in Table 1-1.

Imager

The GOES Imager is a five-channel, multi-spectral imaging radiometer, designed to sense emitted thermal energy and reflected solar energy from sampled areas of the Earth's surface and atmosphere. The Imager provides data for use in determining cloud cover, cloud temperature and height, surface temperature, and water vapor. Using a two-axis gimbaled scan mirror system, the Imager's multi-element spectral channels simultaneously sweep an 8-km north-south (N-S) swath along an east-west (E-W) path at a fixed rate of 20° per second and cover a chosen area by a serpentine scan. The instrument is capable of full Earth imagery, sector imagery that contains the edge of the Earth, and various sizes of area scans totally enclosed within the Earth disk. Area scan selection permits rapid, continuous viewing of local regions for monitoring of mesoscale phenomena and accurate wind determination. Area scan size and location are definable to as small as one pixel to provide complete flexibility and are controlled by a defined set of ground issued commands. All spectral channels are spatially co-registered to each other. The Imager's scanner, in conjunction with the visible detector array provides a star sensing capability to relate the spacecraft location to the scanned area.

Sounder

The GOES Sounder is a 19-channel discrete-filter radiometer, designed to sense emitted thermal energy and reflected solar energy from sampled areas of the Earth's surface and atmosphere to provide data for computing vertical profiles of temperature and moisture, surface and cloud-top temperatures, and ozone distribution.

Table 1-1. GOES N-P Spacecraft Specifications

Communications and T & C		**Power**	
S-band	5 uplinks	**Solar Array**	
S/L-band	7 downlinks	End of life (10 years)	1.9 kW solstice, 2.08 kW equinox
UHF	1 downlink, 2 uplinks	Panels	1 wing with 1 panel of dual-junction gallium arsenide solar cells. Also solar cell circuits on the yoke panel.
T&C	2 downlink, 1 uplink	**Batteries**	24-cell Ni-H_2, 123 A-Hr
Propulsion		**Mass**	
Liquid apogee motor	110 lbf (490 N)	Separated mass	3217.3 kg (7092.9 lb)
Stationkeeping thrusters (bipropellant)	12 x2 lbf (9.25 N)	Dry mass	1545.7 kg (3407.6 lb)
		Propellant and pressurant	1671.6 kg (3685.3 lb)
Antennas		**Launch Vehicle Compatibility**	
2 S/L-band, cup-shaped with dipole		Delta IV	Atlas III
1 omni antenna			
1 UHF, cup-shaped with dipole			
2 L-band cup			
1 S-band horn			

The Sounder has multi-element detector arrays to perform simultaneous sampling of the radiation from a group of four stationary locations in the atmosphere at any given instant. These four fields of view (FOVs) are stepped to cover larger areas with a scan mirror. The infrared (IR) spectral definition is provided by a sequence of filters interposed in the radiation path at each step by a cooled rotating filter wheel. A total of 18 filters in three spectral bands, longwave (LW) (12 μm to 14.7 μm), midwave (MW) (6.5 μm to 11 μm), and shortwave (SW) (3.7 μm to 4.6 μm), are arranged along three concentric rings on the wheel for efficient use of sample time and optimal channel co-registration. In addition, a visible channel using uncooled silicon detectors also samples the same atmospheric locations. The 19 spectral channels provide outputs from each of the four FOVs in each sample (dwell) period, which may be chosen to be at 0.1, 0.2, or 0.4 second intervals. Optionally, scan lines can be skipped to increase area sounding rates.

A two-axis-gimbaled scan mirror system can generate frames of different sizes or locations by stepping the Sounder's FOVs by 280 μrad along an east-west (E-W) path followed by a north-south (N-S) step of 1120 μrad and retracing along a serpentine scan. The stepping motion of the scanner occurs when the optical path is blocked during every rotation of the filter wheel. The instrument is capable of full Earth sounding, sector sounding that contains the edge of the Earth, and various sizes of area scans totally enclosed within the Earth disk. Area scan selection permits rapid, sounding of local regions for monitoring of mesoscale phenomena. Area scan size and location are definable to as small as one pixel sounding location to provide complete flexibility and are controlled by a defined set of ground issued commands. The FOVs of the different channels are spatially co-registered. The Sounder scanner and a second visible detector array provide a star sensing capability to relate the spacecraft location to the scanned area.

Flexible Scan Control

Both the Imager and the Sounder employ a servo-driven, two-axis gimbaled mirror system in conjunction with a 31.1 cm (12.2 inch) diameter aperture Cassegrain telescope. As separate sensors, they allow simultaneous and/or independent surface imaging and atmospheric sounding. Each has flexible scan control, a feature 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 dynamic, short-lived weather phenomena. The GOES area scan capabilities for the Imager are illustrated in Figure 1-3. The scan capabilities of the Sounder are described in the paragraph above. Detailed information on the Imager can be found in Section 3 and on the Sounder in Section 4.

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 3000×3000 km (1864×1864 statute miles) are accomplished in 3 minutes; small area scans of 1000×1000 km (621×621 statute miles) can be made in 41 seconds; the full earth can be imaged in 26 minutes. A 3000×3000 km area can be sounded in 43 minutes.

Space Environment Monitor

The SEM instruments survey the sun and measures in situ its effect on the near-earth solar-terrestrial environment. Changes in this "space weather" can affect the operational reliability of navigation and communication systems, over-the-horizon radar, electrical power transmission, and, most significantly, human crews of the International Space Station, of high altitude aircraft and the U.S. space shuttle. This suite of space environmental monitoring instruments is used to determine when to issue forecasts and alerts of space weather conditions that may interfere with ground and space systems.

The XRS measures the X-ray flux from the sun and provides the primary measure of the magnitude of solar flares. The EUV sensor measures the extreme ultraviolet flux from the sun, which is the primary energy input to the upper atmosphere and ionosphere.

The EPS and HEPAD detect energetic electron and proton radiation trapped within earth's magnetic field as well as direct solar proton, alpha particles and cosmic rays.

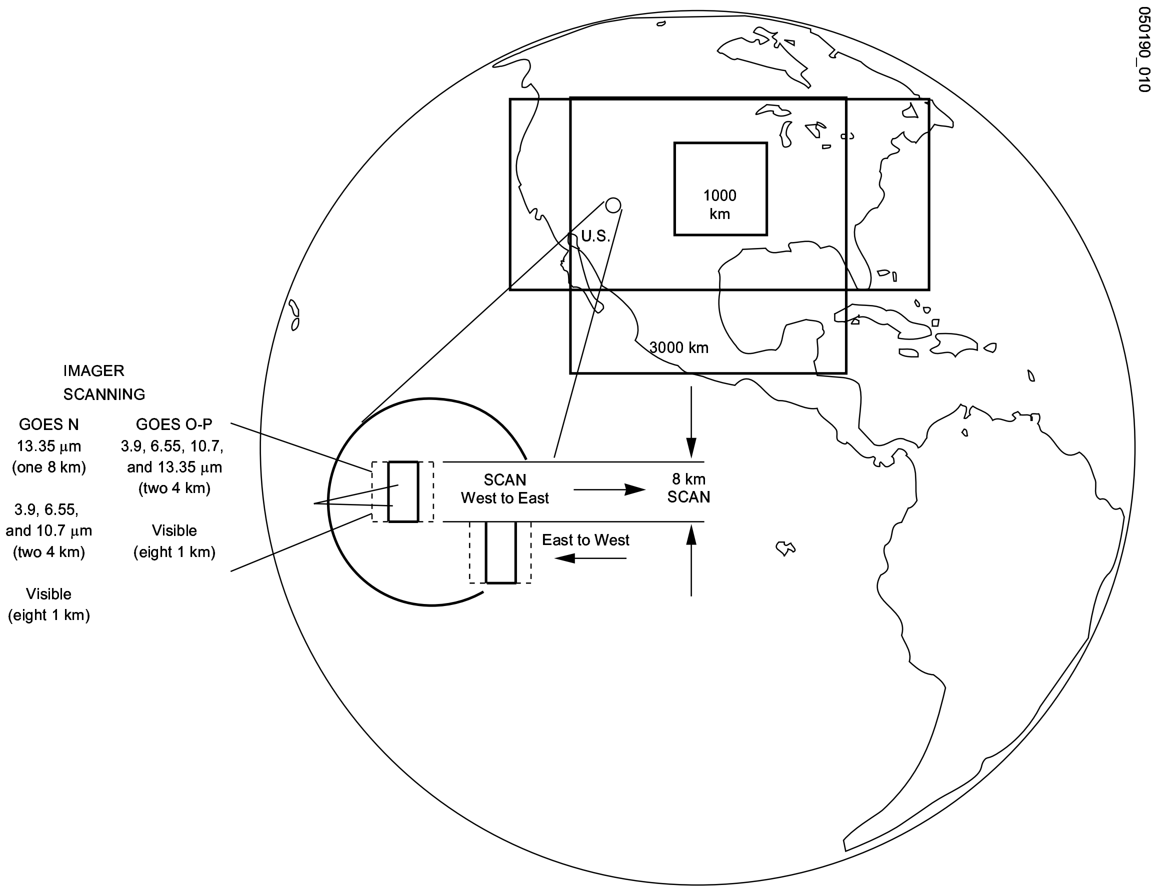


Figure 1-3. Imager Area Scan

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.

Solar X-Ray Imager

The Solar X-ray Imager (SXI) monitors solar disk activity and is used to determine when to issue forecasts and alerts of "space weather" conditions that may interfere with ground and space systems. It is used to locate coronal holes, locate flares on the solar disk, monitor for changes indicating coronal mass ejections, and observe solar active region size, morphology, and complexity. These data are used to predict high speed solar wind streams and solar flare forecasts. The SXI is considered separate from the SEM, and we use that organization in this Data Book. The SXI, XRS, and EUV are mounted on the solar array yoke in order to continuously face the sun.

Other Data Services

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 onboard the spacecraft immediately detects distress signals from downed aircraft or marine vessels and relays the signals 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. Emergency Managers Weather Information Network (EMWIN) relay is new for GOES N-P and is used to broadcast weather related emergency notifications to thousand of users.

Geographic Coverage

The GOES spacecraft, on-station 35,790 km (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 and the South American continent. Pacific coverage includes the Hawaiian Islands and the Gulf of Alaska. Because the Atlantic and Pacific basins strongly influence the weather affecting the United States, coverage is provided by two GOES spacecraft, one—GOES East—at 75° west longitude and the other—GOES West—at 135° west longitude. Geographic coverage for this configuration is shown in Figure 1-5. Alternately, if one spacecraft should fail, the remaining spacecraft can be moved to a central location (100° West) and provide coverage as illustrated in Figure 1-4. The term "useful camera coverage" referenced in the figure refers to the 60° circle coverage provided by the GOES satellite.

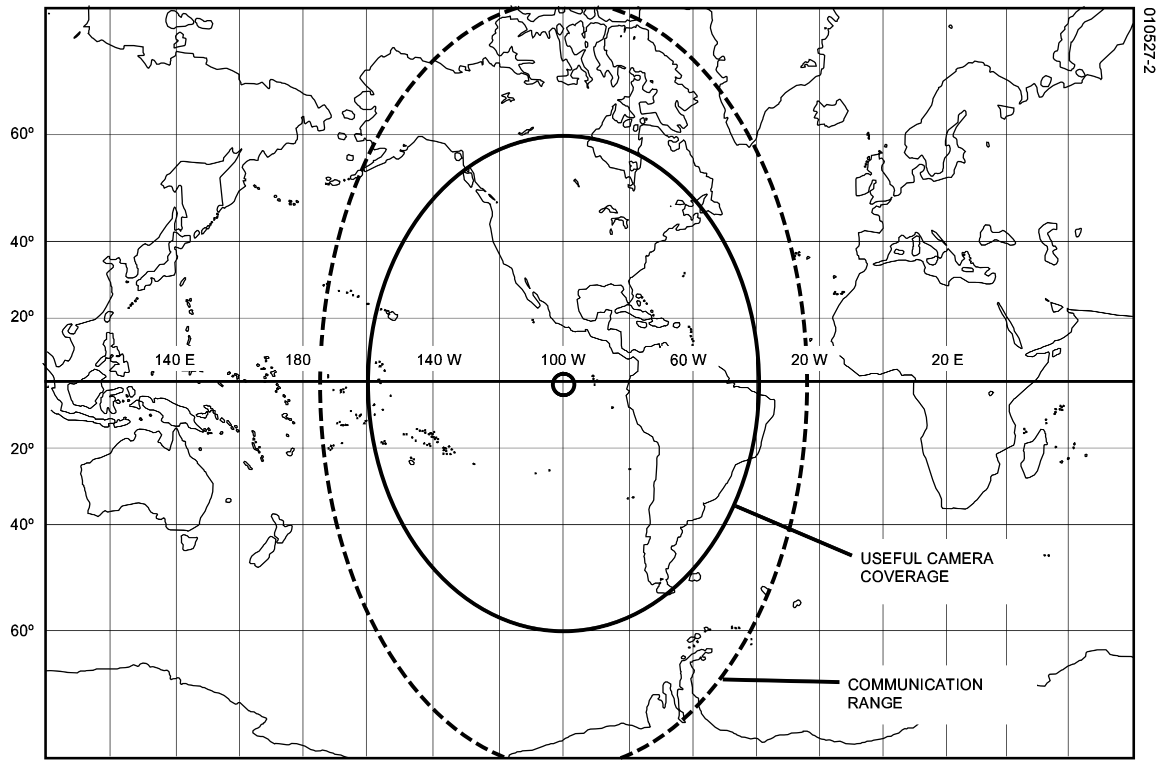


Figure 1-4. GOES Geographic Coverage for Backup One Satellite System

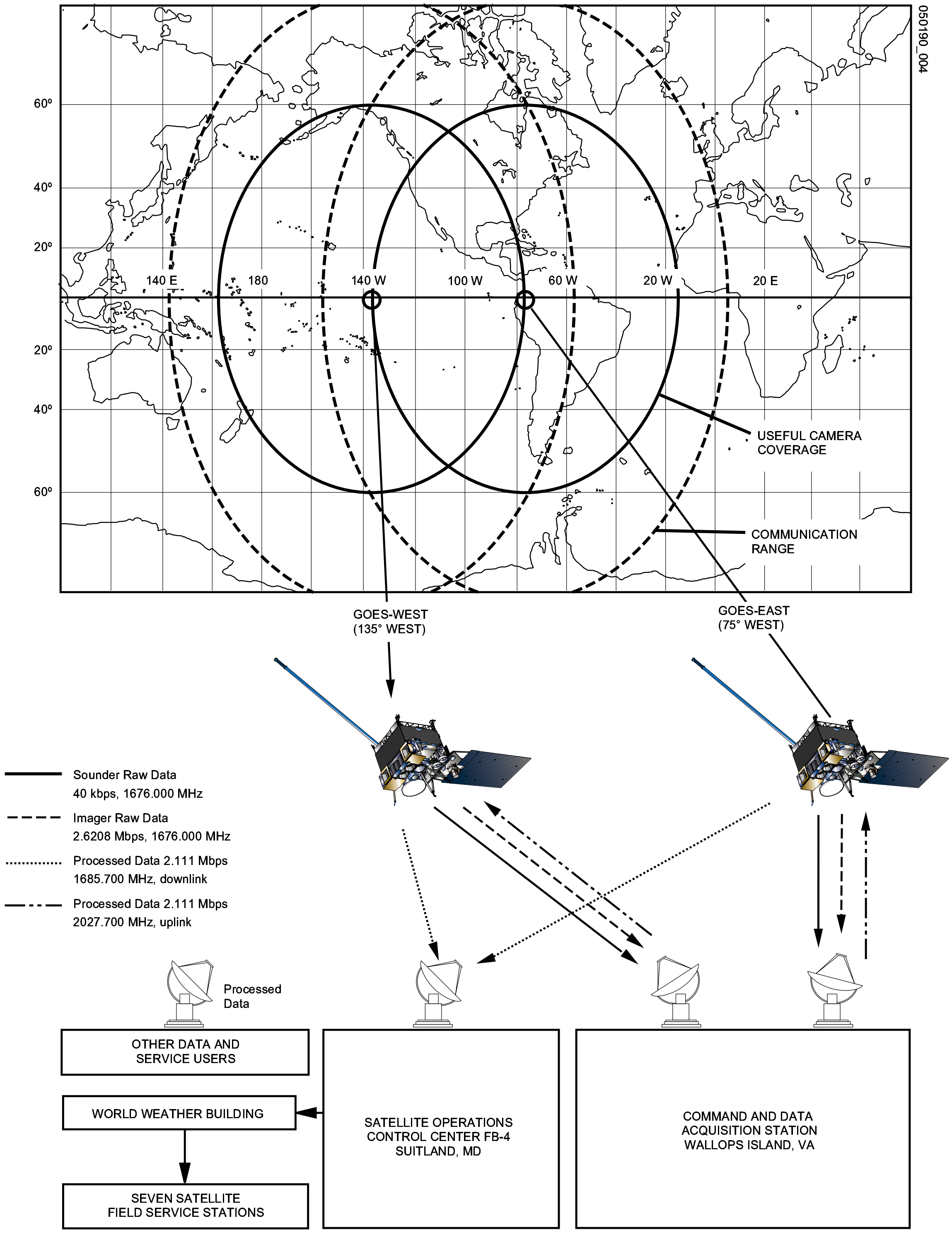


Figure 1-5. GOES Nominal Two Satellite Geographic Coverage and System Functional Architecture

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 has a 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 and end user direct readout ground stations (DRGSs) via the onboard data collection subsystem. Similarly, ground terminals can receive processed environmental data, as well as EMWIN and WEFAX/LRIT transmissions.

Ground Segment

Raw Imager and Sounder data received at the NOAA CDA station are processed in the spacecraft support ground system (SSGS) 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 NOAA 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.

Network Architecture

The communications links are shown in Table 1-2. These links, in conjunction with ground support equipment connectivity and data transmission paths, complete the interfaces among GOES N-P-specific and existing equipment, and are illustrated in Figures 1-2, 1-5, and 1-6. This network, transparent to current users, routes broadcast and mission data. The serial bit streams output by the Imager and the Sounder are transmitted on the L-band carrier by the sensor data transmitter. The GOES spacecraft signal is received at the CDA station, where it is demodulated and processed by the SSGS. The new uplink signal, containing calibrated, earth-located data, is uplinked from the CDA station to the spacecraft, where it is received by the S-band receiver, and converted to the appropriate transmit frequency. Before being multiplexed and retransmitted to user stations by the L-band transmit antenna, the signal is prefiltered to separate it from other uplinked signals.

Table 1-2. Communications Links

Item	Source	Uplink, MHz	Downlink, MHz	Destination
Command	CDA station, DSN	2034.200	---	Spacecraft
Telemetry (including SEM)	Spacecraft	---	1694.000/2209.086	CDA station; DSN; Space Environment Center
Weather Facsimile (WEFAX/LRIT)	CDA station	2033.000	1691.000	Users
Data collection platform interrogate (DCPI)	CDA station	2034.900	468.825	DCP
Data collection platform report (DCPR)	DCP	Domestic: 401.900 International: 402.200	1694.500 1694.800	CDA station; users
Search and rescue (SAR)	Emergency locator transmitter (ELT)	Narrow Band: 406.025 Wide Band: 406.050	1544.500	Mission Control Center
MDL (diagnostic data)	Spacecraft	---	1681.500	SOCC, SEC
Emergency Managers Weather Information Network (EMWIN)	CDA station	2034.700	1692.700	Civil Emergency Managers
Processed Data Relay (PDR)	CDA station	2027.700	1685.700	Users
Sensor Data Downlink (SD)	Spacecraft	---	1676.000	CDA station

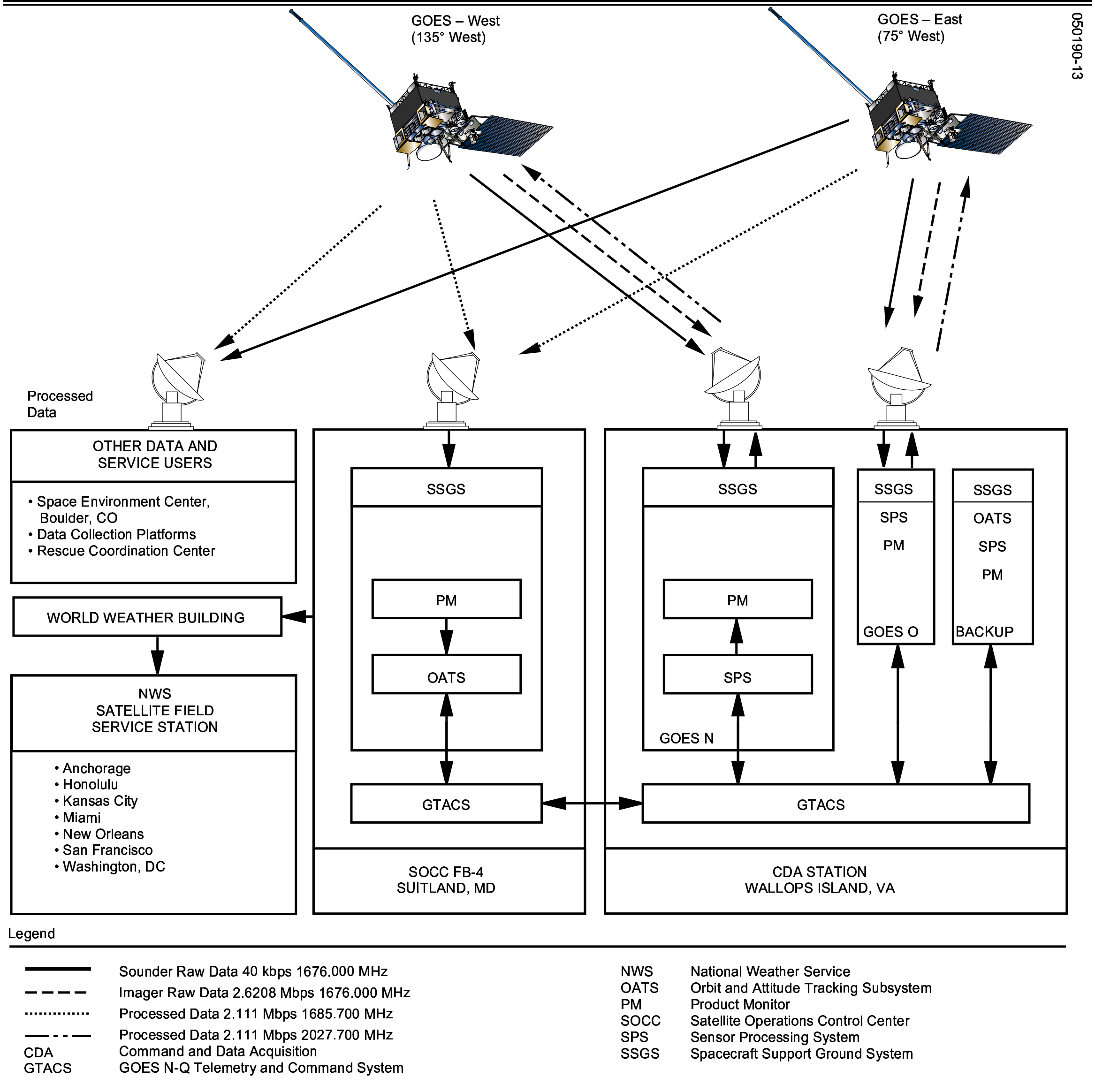


Figure 1-6. Data Transmissions

GOES Processed Data Relay

The GOES PDR data transmission format, referred to as GVAR (GOES Variable Data 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 PDR format originated in the operational visible infrared spin scan radiometer, atmospheric sounder (VAS) mode AAA of the earlier spin-stabilized GOES spacecraft. The AAA format consisted of a repeating sequence of 12 fixed-length, equal size blocks whose transmission was synchronized with spacecraft spin rate (that is, one complete 12-block sequence for each rotation). The range and flexibility of satellite operations are increased by the deployment of the three-axis stabilized

GOES N-P spacecraft, which, like the GOES 8/12 spacecraft, employ two independent instruments, each with a scanning mirror having two degrees of freedom. The use of a fixed-length transmission format would have constrained the operational capabilities of the N-P spacecraft. To fully exploit these capabilities, the GVAR PDR format was developed for the GOES 8/12 spacecraft, supporting variable length scan lines while retaining as much commonality as possible with AAA reception equipment.

Spacecraft Support Ground System

The SSGS consists of components located at the CDA station on Wallops Island, VA, the Wallops Backup CDA station in Greenbelt, MD, and at the SOCC in Suitland, MD. The SSGS receives input streams of raw Imager and Sounder 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 SSGS functions. SSGS elements communicate among each other via the GOES N-P telemetry and command system (GTACS). Within the SSGS, GVAR data are used primarily for monitoring the quality of processed instrument data (CDA station and SOCC), for determining spacecraft range and extracting landmark images as part of orbit and attitude determination, and for monitoring onboard computation of north/south and east/west image motion compensation to provide continuous scan frame registration. In addition, data from the MDL are received at the SOCC as an independent data link. These data are ingested and processed by the SSGS and used for diagnosing dynamic interactions among the instruments and the spacecraft. The MDL is also received by the Space Environment Center (SEC) in Boulder, CO, for the ingest of SXI and SEM data.

This page left blank.