

GOES-NO/P/Q — The Next Generation

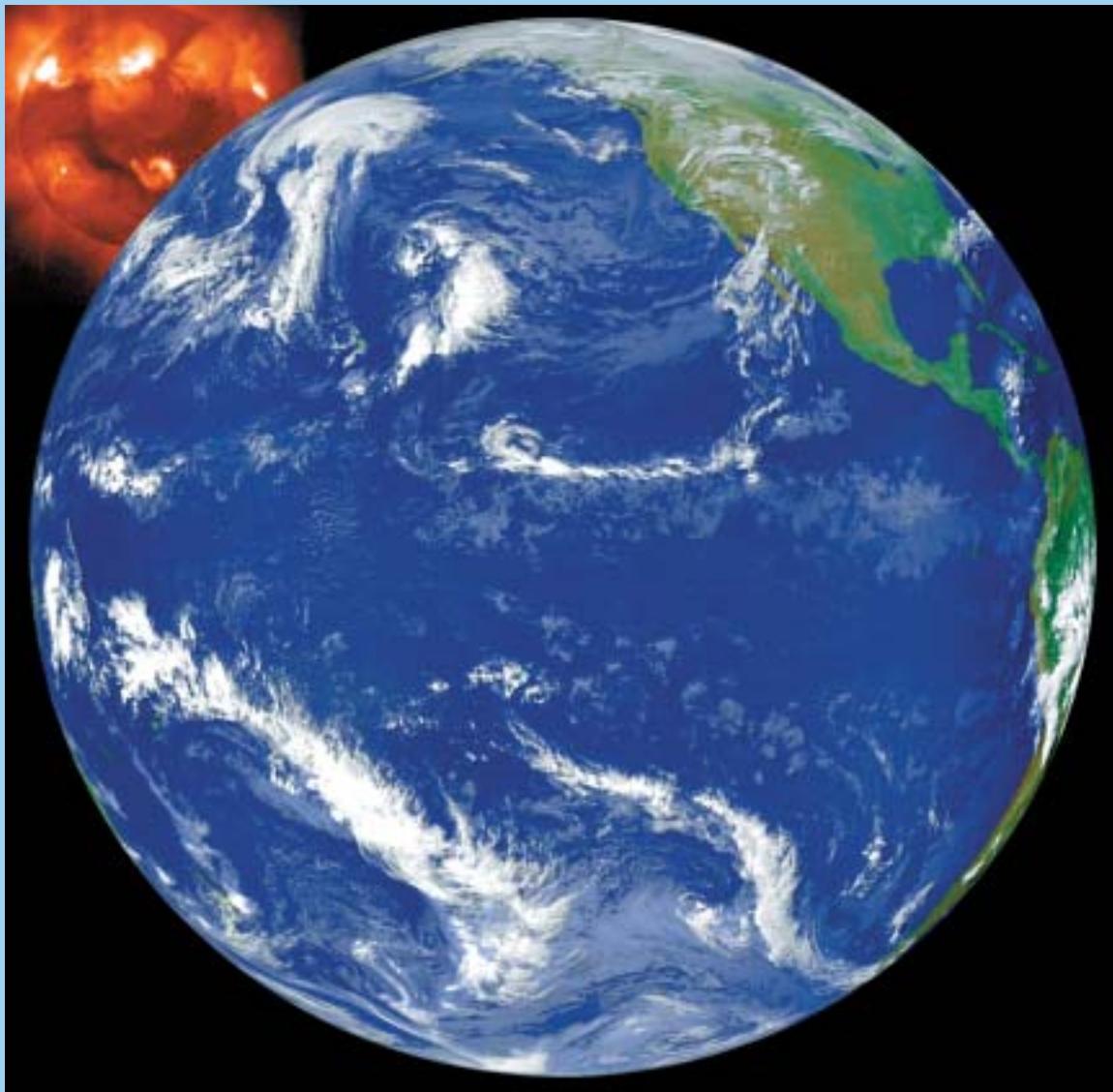


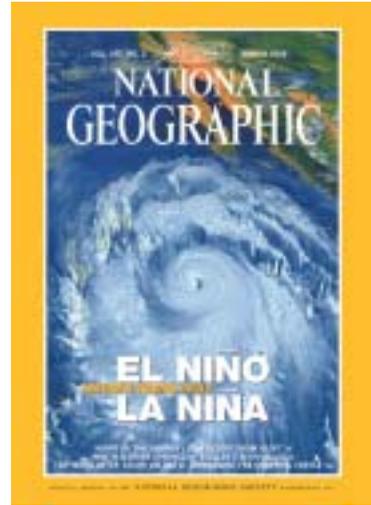
Table of Contents

The Mission	1
Mission History	2
The Spacecraft	4
The Instruments	6
Imager	7
Sounder	8
Space Environment Monitor	9
Solar X-Ray Imager	12
Instrument of Opportunity	14
Search and Rescue	15
Cospas-Sarsat System	15
Launch and Orbit	17
Coverage Area	20
Image Navigation and Registration	21
Data Products and Services	22
Communications	25
Sensor Data	26
Data Collection System	26
LRIT/WEFAX	27
Emergency Managers Weather Information Network	27
Command and Data Acquisition	27
NASA's and NOAA's Roles and Support Systems	28
NASA Support Facilities	28
NOAA Support Facilities	28
Launch Support	29
Prior Spacecraft	29
GOES History	29
GOES Spacecraft Contractors	32
Acronyms and Abbreviations	33

The impressive imagery of cloud cover produced by the Geostationary Operational Environmental Satellites (GOES) series, as viewed from orbit high above the Earth, has become a highlight and staple of television weather forecasts. Forecasting the approach of severe storms for more than 25 years, GOES has remained an essential cornerstone of weather observations and forecasting.

The GOES system of weather satellites provides timely environmental information to meteorologists and their audiences alike—graphically displaying the intensity, path, and size of storms. With El Niño and La Niña affecting people worldwide, GOES images have been featured on the covers of the international press, appearing in *National Geographic*, *Der Spiegel*, and *Life* magazines. GOES images have become so common that many people think of hurricanes in terms of the popularized images of Hurricanes Hugo, Andrew, and Floyd.

The GOES program, begun in 1974, is a joint development effort of the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA). NASA provides launch support and designs, engineers, and procures the satellites. After a satellite is launched and checked out by NASA, it is turned over to NOAA for its operations. NOAA also determines the need for satellite replacement.



GOES spacecraft operate as a two-satellite constellation in geosynchronous orbit above the equator and observe 60 percent of the Earth. They measure the Earth's atmosphere, its surface, cloud cover, and the solar and geosynchronous space environment and provide a platform for the Imager, Sounder, Solar X-Ray Imager (SXI), and space environment monitoring instruments. The system also supports land- and ocean-based Data Collection Platforms (DCPs), transmits Low Rate Information Transmission (LRIT)/Weather Facsimile (WEFAX) and imaging and sounding data between Earth terminals, relays Emergency Managers Weather Information Network (EMWIN) broadcasts, and participates in the international Cospas-Search and Rescue Satellite-Aided Tracking (Sarsat) system.

NOAA and NASA are developing a new series of geosynchronous meteorological satellites that will continue and enhance the current five-satellite GOES series. The new satellite series, designated GOES-NO/P/Q, has several new top-level capabilities. These capabilities include the WEFAX service changing from an analog to a digital LRIT format; expanded measurements for the space environment monitoring instruments; a new dedicated channel for the EMWIN service; and most importantly, a more stable platform for supporting improved Imager, Sounder, and SXI instruments.

Cospas is an acronym for the Russian words *Cosmicheskaya Sistyema Poiska Avariynich Sudov*, which mean "Space System for the Search of Vessels in Distress."

The launch of the prototype Synchronous Meteorological Satellite, *SMS-A*, in May 1974 inaugurated the series of geosynchronous satellites that has provided systematic, continuous observations of weather patterns. A second prototype, *SMS-B*, followed in February 1975. The GOES program formally began with the launch of the first operational spacecraft, *GOES-A*, in 1975, which was renamed *GOES-1* when it reached orbit. *GOES-2* and *GOES-3* followed in 1977 and 1978, respectively. These spacecraft obtained both day and night data on the Earth's weather from the Visible/Infrared Spin Scan Radiometer (VISSR), a scanning instrument that formed images of the Earth's surface and cloud cover for transmission to regional data-user stations for use in weather prediction and forecasting and also for monitoring the space environment.

Geosynchronous satellites orbit the Earth from west to east at an altitude of approximately 22,240 miles or 35,790 km and at a speed that keeps them fixed over the Earth's equator, making one rotation in 24 hours.

A radiometer is an instrument that measures electromagnetic radiation or energy.

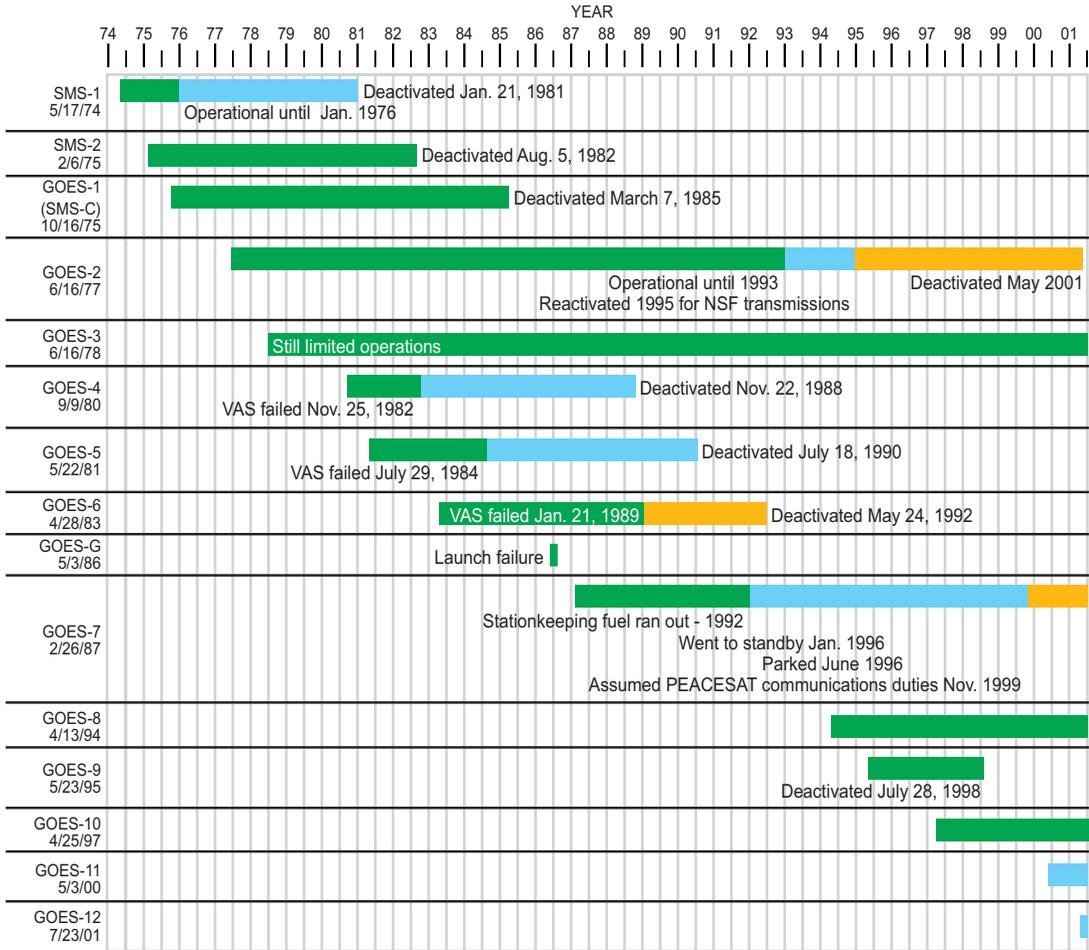
GOES 4-7 were similarly configured. *GOES-4*, launched in 1980, introduced an improved VISSR, the VISSR Atmospheric Sounder (VAS), which gathered the standard VISSR image data and also sounded the atmosphere, enabling meteorologists to acquire temperature and moisture data profiles. From these profiles, scientists could determine the altitudes and temperatures of clouds and draw a three-dimensional picture of their distribution in the atmosphere, leading to more accurate weather predictions. Using GOES imagery, meteorologists also measured the movement of clouds at different altitudes and determined their wind direction and speed to better understand atmospheric circulation patterns. A limitation of the VAS was that it could not gather imaging and sounding data simultaneously but had to alternate between the two functions.

GOES-7, launched in 1987, was the last spinner-type geosynchronous spacecraft. It inaugurated the use of geosynchronous satellites for international search and rescue efforts. The spacecraft could receive signals from emergency transmitters on ships and planes in distress and send them to ground stations that coordinated search and rescue efforts.

"Real-time" is a common term which means that data is collected and relayed to the ground as soon as it occurs.

GOES 8-11 three-axis-stabilized satellites provided significant improvements. *GOES-8*, launched in 1994, carried separate and independently operating Imager and Sounder instruments. Now researchers could gather both imaging and sounding data continuously without having to alternate between the two operating modes. Image resolution also improved significantly, and the GOES search and rescue system also became operational.

The GOES system has continued to improve with new technological innovations and sensors. The present-day GOES spacecraft help meteorologists observe and predict local weather events, including thunderstorms, tornadoes, fog, flash floods, and even snow squalls. GOES



Legend:
 NSF - National Science Foundation
 SMS - Synchronous Meteorological Satellite
 VAS - VISSR Atmospheric Sounder
 VISSR - Visible/Infrared Spin Scan Radiometer
 WEFAX - Weather Facsimile
 Launch / Active Period
 Standby / Inactive
 Diminished capability / Other function assumed

Mission History Summary

observations have proven helpful in monitoring dust storms, volcanic eruptions, and forest fires. Currently, the system consists of *GOES-8*, operating as *GOES-East* in the eastern part of the constellation at 75° west longitude, and *GOES-10*, operating as *GOES-West* at 135° west longitude. *GOES-11* is in standby mode and is serving as a spare that backs up both satellites. *GOES-12* was successfully launched from Cape Canaveral on July 23, 2001. See “Prior Spacecraft” beginning on page 29 for more detailed information about each spacecraft.

Overall, the program continues to provide environmental data for routine meteorological analyses and forecasts, serve user agencies, and provide environmental data that helps expand knowledge of storm development and forecast severe weather events. It supports the Cospas-Sarsat system, contributes to the development of worldwide environmental warning services and enhancements of basic environmental services, improves the capability for forecasting and providing real-time warning of solar disturbances, and provides data that may be used to extend knowledge and understanding of the atmosphere and its processes.

The GOES-NO/P/Q spacecraft, built by Boeing Satellite Systems, Inc. (formerly Hughes Space and Communications), are based on the Boeing 601 spacecraft and are the latest in the series of three-axis body stabilized geosynchronous weather satellites. The new

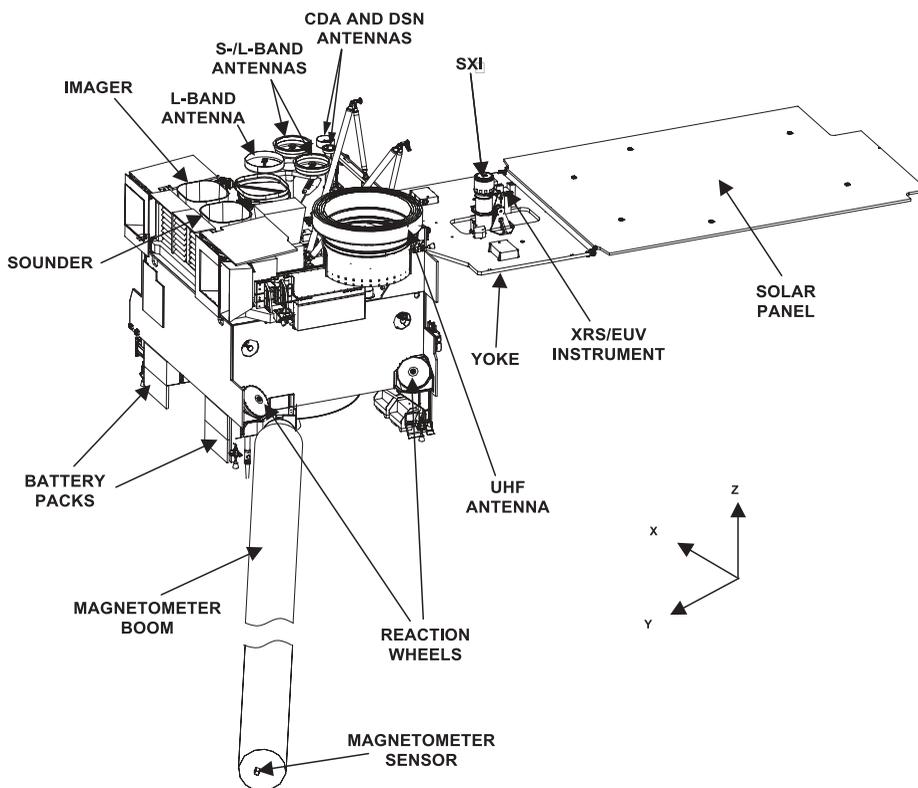


Spacecraft Description Summary

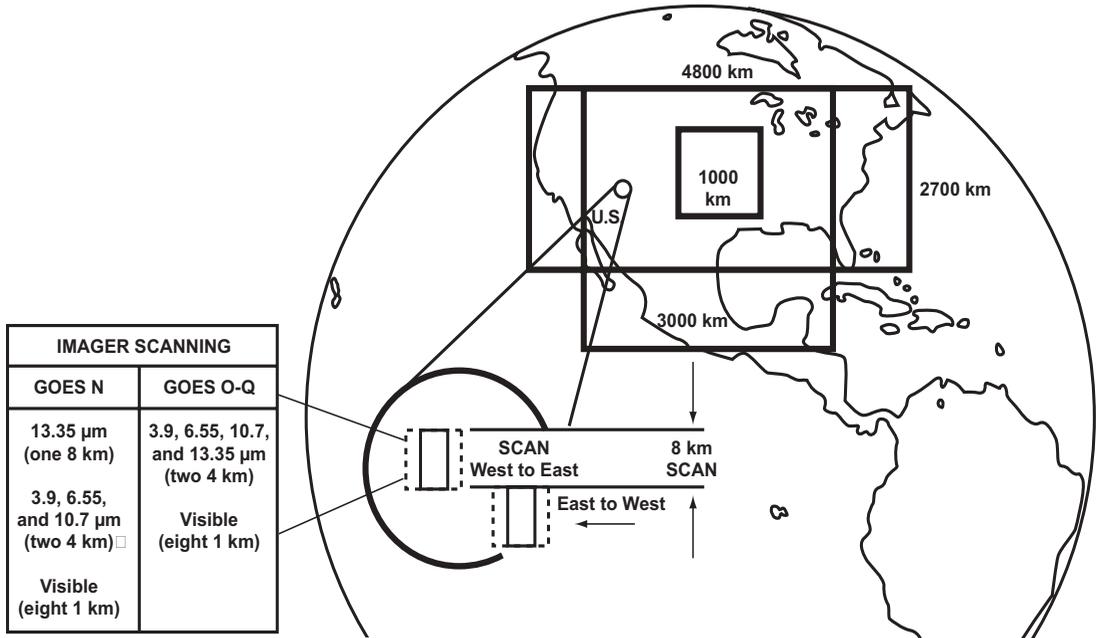
On-Orbit Configuration	Length (solar array to spacecraft body):	331 in. (8.4 m)
	Height (Imager port to magnetometer boom):	358 in. (9.1 m)
	Depth:	113 in. (2.9 m)
	Solar array: Yoke panel:	28 ft. 8 in. (8.2 m) 7 ft. 9 in. x 6 ft. 0.1 in. (2.3 m x 1.8 m)
Mass	At launch:	7,075.7 lb. (3,209.5 kg) (including fuel, oxidizer, and pressurant)
	Dry mass:	3,402 lb. (1,543 kg)
Power	Beginning of life:	2.22 kW at summer solstice, 2.47 kW at equinox
	End of life:	2.07 kW at summer solstice, 2.25 kW at equinox
	Battery:	Nickel hydrogen (NiH ₂)
	Battery capacity:	123 ampere-hours
Propulsion	Fuel:	Monomethylhydrazine
	Oxidizer:	Nitrogen Tetroxide
	Pressurant:	Helium
Launch Vehicle	Delta III (also Atlas III-compatible)	
Lifetime	Five years of operations plus two years of on-orbit storage. Five years of ground storage is also possible.	

satellites will accurately locate severe storms and other weather phenomena, resulting in precise warnings to the public. The spacecraft enable the primary sensors to “stare” at the Earth and thus frequently image clouds, monitor the Earth’s surface temperature, and sound the Earth’s atmosphere for its vertical temperature and water vapor distribution. Atmospheric phenomena can be tracked, ensuring real-time coverage of events such as severe local storms, tropical hurricanes, and cyclones—meteorological events that directly affect public safety, property, and ultimately, economic health and development. The figure below shows the GOES spacecraft in its on-orbit configuration.

The spacecraft subsystems, such as telemetry and command, communications, mechanical, electrical, power, propulsion, attitude control, and image navigation and registration, have been designed to support the requirements of the on-board instruments and the data products and services that are described in this brochure.



GOES On-Orbit Configuration



Each range of Imager wavelengths generates images with square pixels that are 1 km, 4 km, or 8 km on each side. For instance, images produced at wavelengths of 10.20 - 11.20 micrometers (μm) have pixels that are 4 km (2.5 miles) on each side. A smaller number of pixels indicate better-quality images. Note that the resolution for the 13.00 - 13.70 μm wavelength changes for GOES-O-Q.

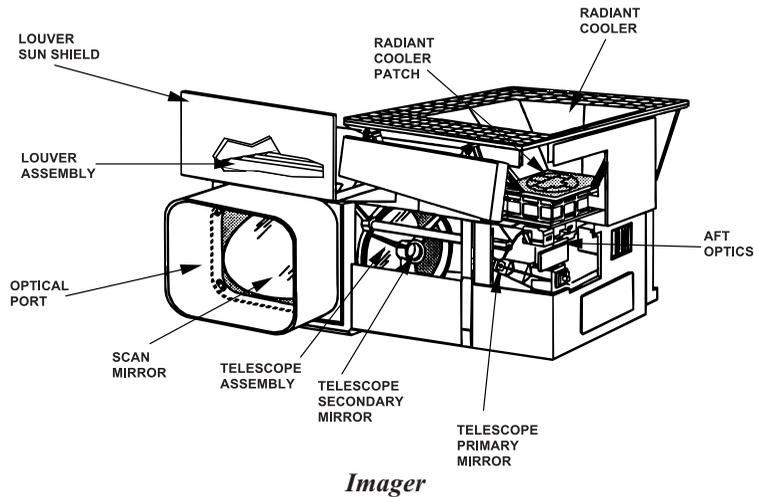
GOES Area Scan

The GOES-NO/P/Q spacecraft carry an Imager, a Sounder, and a collection of other space environment monitoring instruments. Both the Imager and the Sounder have a flexible scan control mechanism that allows the instruments to scan small areas as well as all of North and South America and global scenes (called full-disk images). Small area scan selection permits rapid and continuous viewing of local areas for monitoring of regional phenomena and accurate wind determination. The scan control mechanism also allows continuous observations of severe storms and changing, short-lived weather phenomena. Commands from the NOAA control center select the position and size of the area for observation.

The resolution, or clarity, of each image depends on the size of the picture elements (pixels) in the image that is being acquired. The size of each pixel, in turn, depends on which band is being used. Different bands take images with different-size pixels (see “Imager Scanning” table above). An image with pixels that are 4 km (2.5 miles) on each side provides twice the resolution of an image whose pixels are 8 km (5 miles) on each side. All Sounder channels generate data that have circular pixels with 10-km (6.2-mile) diameters.

Imager

The Imager, developed by ITT A/CD (ITT Aerospace/Communications Division), Fort Wayne, Indiana, is an imaging radiometer that uses data obtained from its five channels to continuously produce images of the Earth's surface, oceans, severe storm development, cloud cover, cloud temperature and height, surface temperature, and water vapor. It allows users to identify fog at night, distinguish between water and ice clouds during daytime hours, detect hot spots (such as volcanoes and forest fires), locate a hurricane eye, and acquire measurements of nighttime ground and sea surface temperatures.



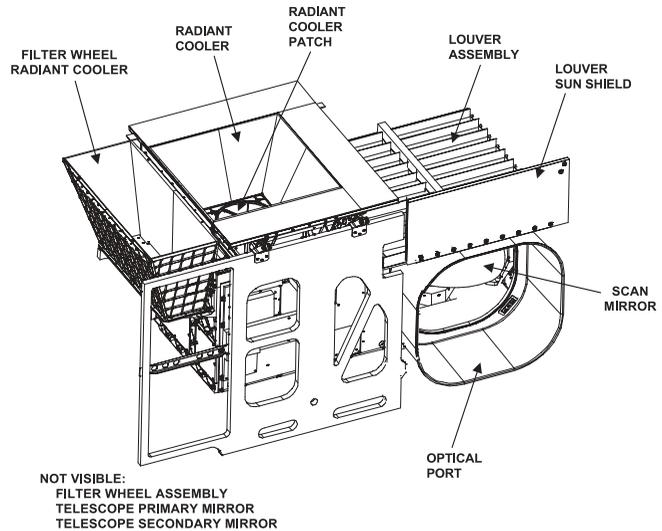
The Imager simultaneously senses emitted thermal and reflected solar energy from selected areas of the Earth. It uses a scan mirror system to alternately sweep east to west and west to east perpendicular to a north-to-south path. The rate of scanning allows the instrument to gather data in its five spectral channels from a 1,864 x 1,864-mile area (3,000 x 3,000 km) in three minutes and from an area of 621 x 621 miles (1,000 x 1,000 km) in just 41 seconds.

Imager Data Products

Wavelength (μm)	Products	Pixel size (km)
visible - 0.52 - 0.71	Daytime cloud cover	1
3.73 - 4.07	Nighttime cloud cover	4
5.80 - 7.30	Water vapor	4
10.20 - 11.20	Earth and cloud images; sea surface temperature and water vapor	4
13.00 - 13.70	Cloud cover and cloud height	8 on GOES-N; 4 on GOES O-Q

Sounder

The Sounder, also built by ITT A/CD, provides meteorologists with a detailed description of conditions in the atmosphere at any time. It gathers data over an approximately circular area extending from 60° north to 60° south latitude, allowing meteorologists to deduce atmospheric temperature and moisture profiles, surface and cloud-top temperatures, and ozone distributions by mathematical analysis and by adding to data from the Imager. Sounder data is also used in computer models that produce mid- and long-range weather forecasts.



Sounder

Detecting conditions that may lead to severe storms is one major function of the Sounder. Data collected by the instrument is processed on the ground so that it generates a numerical designation called a “lifted index,”

which is an indicator of atmospheric stability and of how much air near the surface would keep rising were it lifted to the middle of the atmosphere. The less stable the atmosphere, the greater the likelihood of severe storms.

The Sounder probes the atmosphere measuring emitted radiation in one visible band and 18 thermal bands that are sensitive to temperature, moisture, and ozone as well as to reflected solar radiation. It measures radiated energy at different depths (altitudes) and also records surface and cloud-top temperatures and ozone distribution. It looks

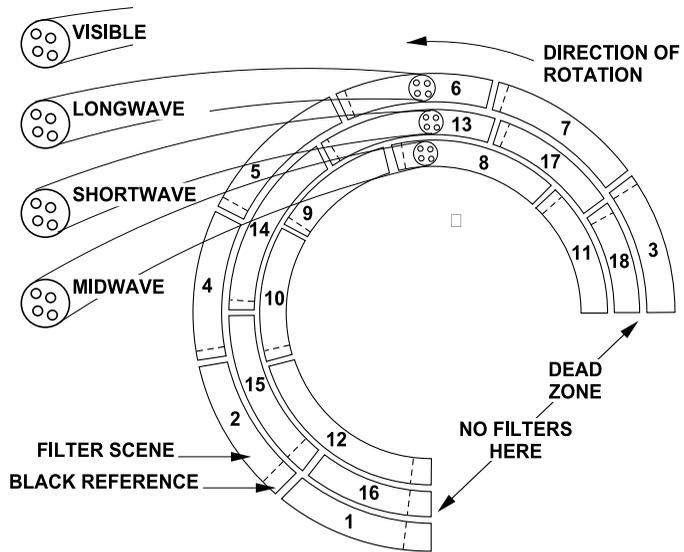
Sounder Channel Allocation and Purpose

Detector	Channel Number	Central Wavelength (μm)	Purpose
Longwave	1	14.71	Temperature sounding
	2	14.37	Temperature sounding
	3	14.06	Temperature sounding
	4	13.64	Temperature sounding
	5	13.37	Temperature sounding
	6	12.66	Temperature sounding
	7	12.02	Surface temperature
Midwave	8	11.03	Surface temperature
	9	9.71	Total ozone
	10	7.43	Water vapor
	11	7.02	Water vapor
	12	6.51	Water vapor
Shortwave	13	4.57	Temperature sounding
	14	4.52	Temperature sounding
	15	4.45	Temperature sounding
	16	4.13	Temperature sounding
	17	3.98	Surface temperature
	18	3.74	Surface temperature
Visible	19	0.70	Clouds

at conditions in “columns” of the atmosphere—cylindrical sections that extend from the Earth’s surface to the upper reaches of the atmosphere.

The Sounder operates by means of a scan mirror that steps across the disk of the Earth in a west-to-east and east-to-west direction along a north-to-south path as the filter wheel rotates.

The filter wheel has 18 filters, each of which corresponds to a particular band or wavelength in the spectrum. Each filter allows only energy with a particular wavelength to reach the detectors. All 18 filters and the visible band are sampled during each rotation, which occurs 10 times per second.



Sounder Filter Wheel Assembly

One-fourth of the wheel has no filters, which allows time for the scanner to move, or “step,” to a new scan position during the period of rotation. For the visible band, the reflected solar energy bypasses the filter wheel completely and goes directly to the 19th channel visible detector. The Sounder’s detector array assemblies sample four separate fields or atmospheric columns simultaneously.

The Sounder operates independently of and simultaneously with the Imager, using a similar type of flexible scan mechanism system. The Sounder scans the full Earth and can be commanded to scan and provide soundings of local regions of interest. It can provide imagery over the entire area that is visible to the Sounder, sector imagery, and scans of local regions. Sounder data from the chosen scan area is fed into powerful computer programs that develop advanced numerical weather prediction models for use by weather forecasters.

Space Environment Monitor

The Space Environment Monitor (SEM) consists of three instrument groups: 1) an energetic particle sensor (EPS) package, 2) two magnetometer sensors, and 3) a solar x-ray sensor (XRS).

Operating at all times, the SEM provides real-time data to the Space Environment Center (SEC) in Boulder, Colorado. The SEC, as the nation’s “space weather” center, receives, monitors, and interprets a wide variety of solar terrestrial data and issues reports, alerts, warnings, and forecasts for special events such as solar flares and geomagnetic storms (see <http://www.sec.noaa.gov>).

This information is important for military and civilian radio communication, satellite communication and navigation systems, electric power networks, geophysical exploration, Shuttle and Space Station astronauts, high-altitude aviators, and scientific researchers.

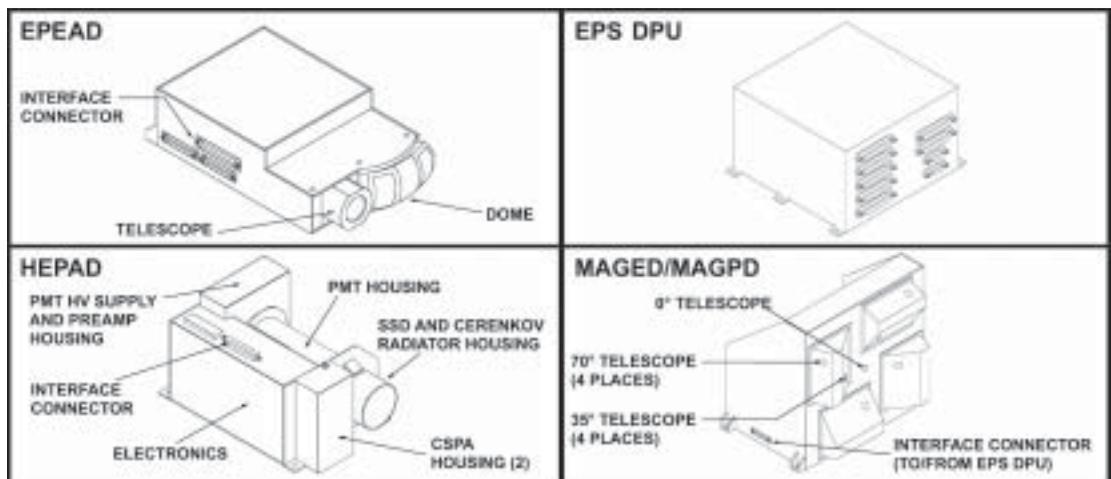
Energetic Particle Sensor

The EPS, developed by Panametrics, Inc., measures the energetic particles at geosynchronous orbit, including protons, electrons, and alpha particles. The radiation in the environment consists of particles trapped within the Earth's magnetosphere as well as particles arriving directly from the sun and cosmic rays that have been accelerated deep in space.

The sensors accurately measure the number of particles over a broad energy range and are the basis for operational alerts and warnings of hazardous conditions. Energetic particles pose a risk to satellites and to astronauts, and they can disrupt navigation and communications systems used on the ground and in aircraft.

The Magnetosphere Electron Detector (MAGED) and Energetic Proton, Electron, and Alpha Detector (EPEAD), two elements of the EPS, detect electrons over the energy range of 30,000 electron volts (30 keV) to greater than 4 million electron volts (4 MeV), in eight channels. The Magnetosphere Proton Detector (MAGPD), EPEAD, and High Energy Proton and Alpha Detector (HEPAD), which are additional EPS elements, detect protons over the energy range of 80 keV to greater than 700 MeV, in 16 channels. The EPEAD and HEPAD detect alpha particles over the energy range 3.8 MeV to greater than 3,400 MeV, in eight channels.

The continuous long-term monitoring of the environment provided by these sensors forms the basis for engineering guidelines for satellite design, for analyzing satellite failure and anomalous behavior, for assessing the risk of human exposure to radiation, and for research leading to im-

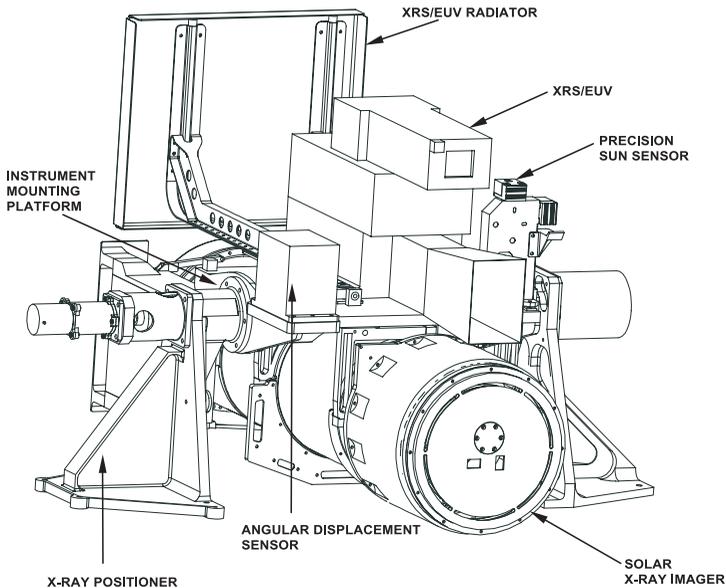


Elements of the EPS: the EPEAD, EPS DPU, HEPAD and MAGED/MAGPD

proved models of the radiation environment. The sensors on the EPS have been expanded on GOES-NO/P/Q to provide coverage over an extended energy range and with improved directional accuracy.

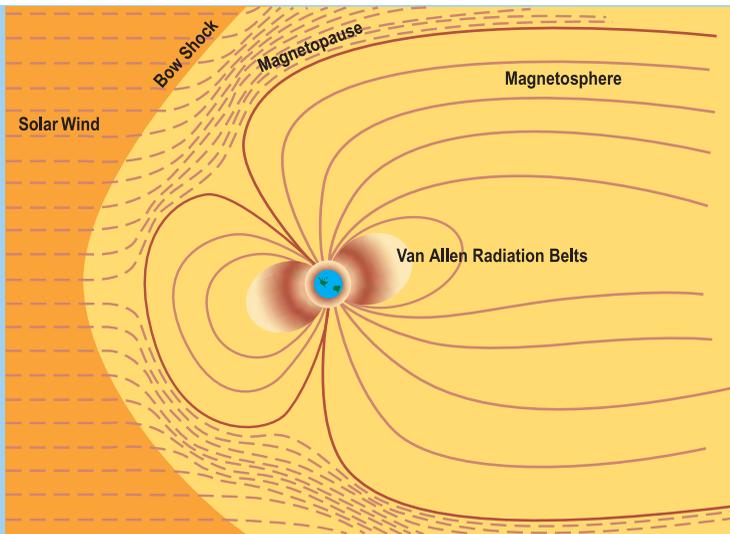
Magnetometers

The GOES-NO/P/Q satellites have two identical magnetometers, provided by Science Applications International Corporation (SAIC), Inc. They can operate independently and simultaneously to measure the magnitude and direction of the Earth's geomagnetic field, detect variations in the magnetic field near the spacecraft, provide alerts of solar wind shocks or sudden impulses that impact the magnetosphere, and assess the level of geomagnetic activity. Magnetometer data is archived for the scientific community and other interested users. One magnetometer is mounted on the end of the boom 27.9 feet (8.5 m) from the spacecraft. The other is positioned on the same boom 2.6 feet (0.8 m) closer to the spacecraft. The second magnetometer sensor serves as a backup in case the first magnetometer sensor fails and provides for better calibration of the magnetometer data channel.



GOES Sun-Observing Package

The magnetosphere is the comet-shaped region around the Earth that is affected by the Earth's magnetic field. It extends some 37,282 miles (60,000 km) from the Earth on the side facing the sun, but on the opposite side, it extends much farther. The boundary of the magnetosphere is called the "magnetopause." Read about the magnetosphere at <http://www-istp.gsfc.nasa.gov/Education/>.



X-Ray Sensor and Extreme Ultraviolet Sensor

The XRS is an x-ray telescope that observes and measures solar x-ray emissions in two ranges—one from 0.05 to 0.3 nanometers (nm) and the second from 0.1 to 0.8 nm. In real-time, it measures the intensity and duration of solar flares in order to provide alerts and warnings of potential geophysical responses, such as changes in ionospheric conditions, that can disrupt radio communications and Global Positioning System (GPS) signals. XRS data is also used to estimate solar flare parameters such as rise-time (how quickly a flare grows) and the length and temperature of a flare for use in energetic proton predictions.

The five-channel EUV telescope is new on the GOES-NO/P/Q satellites. It measures solar extreme ultraviolet energy in five wavelength bands from 10 nm to 126 nm. The EUV sensor provides a direct measure of the solar energy that heats the upper atmosphere and creates the ionosphere. Changes in solar EUV output can change the density of the upper atmosphere by a factor of 10, which will cause increased drag for satellites in low-Earth-orbit. Similarly, these changes in EUV level can increase the density of the ionosphere by a factor of 10, which will affect radio communications and satellite navigation.

Both the XRS and EUV are provided by Panametrics, Inc., and are part of the sun-observing package mounted on the solar panel yoke assembly. The entire package (including the SXI) continually points at the sun by using a Precision Sun Sensor (PSS) to control the solar panels to track the sun in azimuth and the x-ray positioner (XRP) to track the sun in elevation.

Solar X-Ray Imager

The SXI, developed by Lockheed Martin Advanced Technology Center (LMATC), uses a telescope assembly to observe the sun's x-ray emissions and provide early detection and location of flares. These observations allow space weather forecasters to monitor solar features and activities such as solar flares, loops, coronal holes, and coronal mass ejections—clouds of charged particles shooting toward Earth—from the sun. Knowledge of the location and size of these phenomena greatly improves the forecaster's ability to predict which solar phenomena may affect the Earth and its atmosphere and to determine when forecasts and alerts of space weather conditions that may interfere with ground and space systems should be issued.

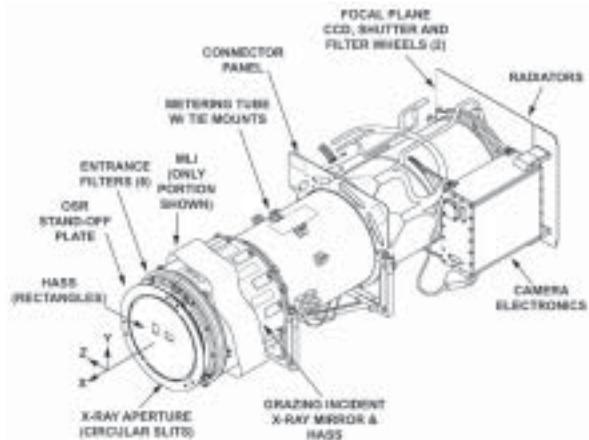
Space Environment Monitoring Terminology

Cosmic rays - A rain of fast ions that constantly bombards the Earth, coming from distant space and much more energetic than any found in the magnetosphere.

Ionosphere - A region of the upper atmosphere that extends from about 30 miles (50 km) to 250 miles (400 km) above the Earth's surface. It is characterized by the presence of ions and electrons that affect radio communications and satellite navigation.

Magnetometer - An instrument that measures the magnitude and direction of the Earth's magnetic field.

Space weather can have quite far-reaching effects. NOAA categorizes these as radio blackouts, radiation storms, and geomagnetic storms. Radio blackouts interfere with military and commercial communications and navigation systems. Radiation storms can damage operating spacecraft and expose humans to excessive radiation during high-altitude missions. Geomagnetic storms damage power utility systems and disrupt communications and navigation systems.



SXI Telescope Assembly

NOAA and U.S. Air Force forecasters will use data and images from the SXI to monitor solar conditions that affect space weather conditions, including the dynamic environment of energetic particles, solar wind streams, and coronal mass ejections emanating from the sun.

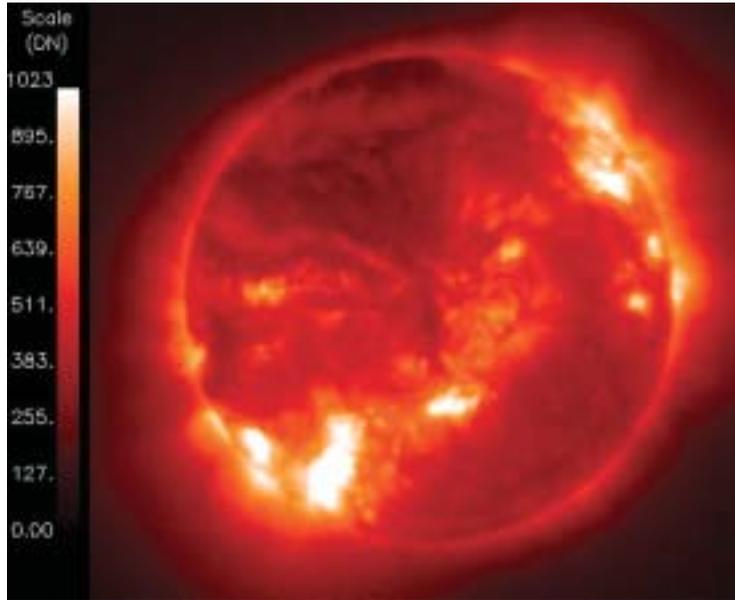
The SXI captures full-disk images of the sun in the x-ray spectral band from 0.6 to 6.0 nm. It is commanded from the ground and can capture at least one image per minute. Ground command can reconfigure the SXI to take image sequences with varying exposure times in different parts of the x-ray spectral band, depending on the level of solar activity. If enabled by ground command, the instrument can also automatically change its imaging sequences during very high solar activity.

The telescope consists of entrance filters that block radiation outside the 0.6-to-6.0-nm range and also protect the Charge Coupled Device (CCD) from undesired radiation. The SXI's x-ray mirror focuses the image on the camera, while the High Accuracy Sun Sensor (HASS) keeps the instrument focused on the sun in the east-west direction.



Solar X-Ray Imager

Images are captured in digital form on the CCD. From there, they are transmitted directly to NOAA's SEC, which processes the data in real time for its own use and use by others in predicting space weather. In processing the data, the SEC corrects known image defects and calibrates and stores each image. The calibrated images are used to automatically locate solar flares, produce movie sequences, calculate



The SXI provides real-time transmissions of x-ray images of the sun through its unprecedented monitoring of solar changes. In this image, the brightest spots indicate solar flares—explosive releases of plasma from the sun’s surface into its atmosphere. Coronal holes appear as dark regions. They are associated with weak magnetic field lines and indicate sources of geomagnetic storms. This image was produced on September 7, 2001, by the first SXI, flown on GOES-12. It was built by NASA’s Marshall Space Flight Center.

coronal hole indices, display on real-time monitors, and produce products for the general public. The user will be able to view PNG and MPEG files* and order high-fidelity images for research. Data will be archived at the NOAA National Geophysical Data Center (NGDC) at <http://www.ngdc.noaa.gov>.

Instrument of Opportunity

The GOES-NO/P/Q spacecraft are designed so they can accommodate an additional observational instrument. This instrument of opportunity would be provided by universities, research institutions, or other organizations that have expressed an interest, can finance the costs associated with the opportunity, and can meet the instrument accommodation requirements.

At present, no instruments of opportunity have been identified for inclusion on any of the GOES spacecraft in the NO/P/Q series.

*PNG and MPEG are file formats for viewing graphics and motion pictures.

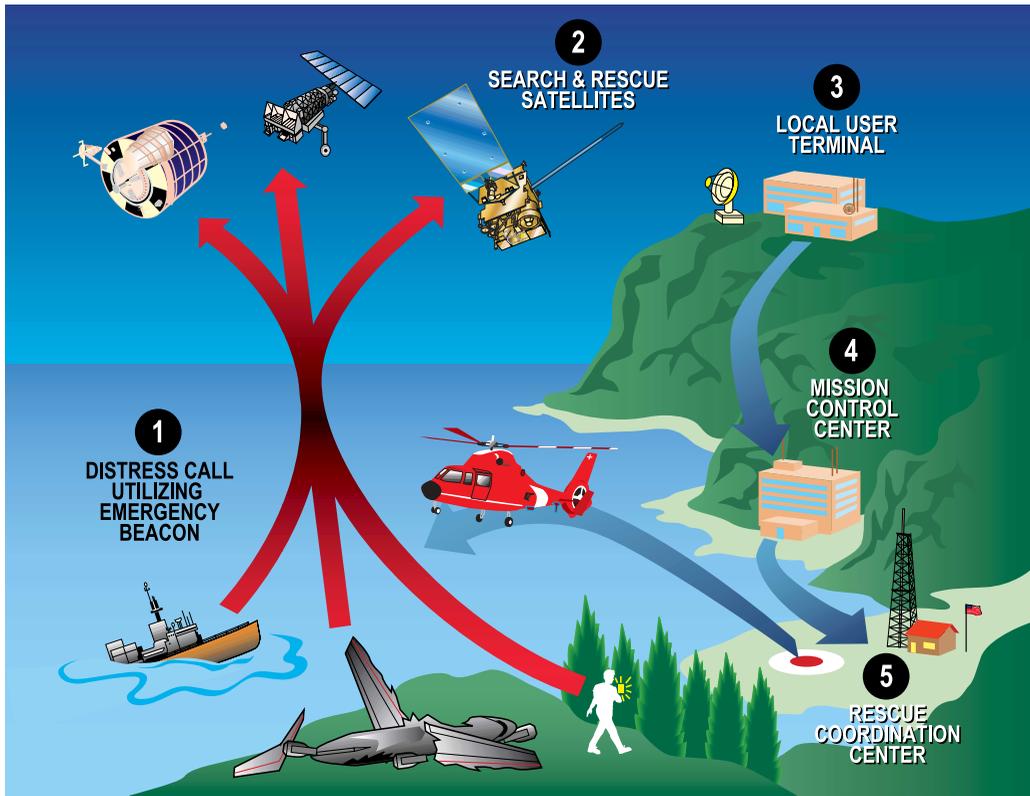
Cospas-Sarsat System

GOES spacecraft carry a search and rescue transponder that detects signals transmitted by 406-MHz emergency beacons carried by aircraft (Emergency Locator Transmitters—ELTs), maritime vessels (Emergency Position Indicating Radio Beacons—EPIRBs) and individuals (Personal Locator Beacons—PLBs). Optional GPS-equipped beacons will allow GOES spacecraft to precisely locate distress signals and significantly improve the response time for providing rescue assistance.

When the transponder on a GOES satellite detects an alert, it transmits the alert from the spacecraft to a Local User Terminal (LUT) in Canada called a GEOSAR Ground Station. (Another geosynchronous LUT will soon be installed at Suitland, Maryland.) When the LUT receives the search and rescue data, it determines the distress location and forwards the data to the U.S. Mission Control Center (USMCC) at Suitland, Maryland. The signals sent by the GOES spacecraft can be used in conjunction with the signals sent by the polar-orbiting satellites in low-Earth-orbit to determine the location of the distress call. Satellites in low-Earth-orbit transmit alerts they receive to a LUT located within the field of view of the satellite. U.S. LUTs for satellites in low-Earth-orbit are located at Fairbanks, Alaska; Vandenberg Air Force Base, California; Wahiawa, Hawaii; Johnson Space Center, Houston, Texas; NOAA, Suitland, Maryland; Anderson Air Force Base, Guam; and Sabana Seca, Puerto Rico.

When the location of the distress call is determined, the MCC identifies the appropriate Rescue Coordination Center (RCC) and forwards the distress data after removing redundant information. Additional LUTs and MCCs are located in Canada, France, Russia, and 10 other cooperating countries. All MCCs cooperate in forwarding data to provide rapid global delivery of distress locations received through the satellites.

The U.S. portion of the Cospas-Sarsat system is operated by the NOAA SARSAT Office in Suitland, Maryland. Additional information about the system, including the latest U.S. and worldwide lives saved, can be obtained at <http://www.sarsat.noaa.gov>. As of June 2001, more than 12,800 lives have been saved around the world.



Cospas-Sarsat System

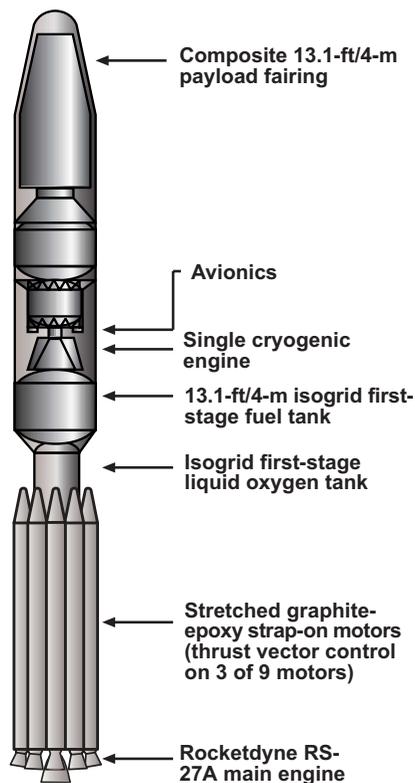
1. Emergency beacons are activated in situations of “grave and imminent danger” when lives are at risk.
2. Emergency alerts received by the satellites are retransmitted to one or more of 38 automatic (unstaffed) ground stations worldwide. These stations are called Local User Terminals (LUTs).
3. Messages are routed to a Mission Control Center (MCC) in the country that operates the LUT. Routed messages include beacon location computed at the LUT if the message was received by one of the system’s low-Earth-orbiting satellites. Messages received by system satellites in geosynchronous orbit provide instantaneous alerting and can include location information if the beacon is a self-locating type.
4. After validation processing, alerts are relayed depending on beacon location or country of registration (406-MHz beacons only) to either another MCC or to the appropriate Rescue Coordination Center (RCC).
5. The U.S. Coast Guard and Air Force operate U.S. RCCs. The Air Force Rescue Coordination Center at Langley AFB, Virginia, coordinates all inland search and rescue activities in the lower 48 states. Usually, the actual search and rescue is carried out by the Civil Air Patrol or local rescue services. The Coast Guard coordinates and conducts most maritime search and rescue missions from RCCs located in nine Command Districts around the United States and two Rescue Sub-Centers (RSCs) in San Juan, Puerto Rico, and Guam. The Coast Guard also coordinates rescue missions in Hawaii.

In Alaska, the Air Force operates an Alaskan Rescue Coordination Center in Anchorage at Ft. Richardson. Air National Guard units, the Alaska State Police, and local authorities carry out Alaskan search and rescue.

A Delta III space launch vehicle (SLV) will be used to launch *GOES-N* and *GOES-O*. This SLV has evolved from the Delta II, which has been successfully used for more than 10 years. The Delta III, provided by Boeing, is a two-stage vehicle with a payload fairing, payload attach assembly, and avionics system. It can deliver a payload of 8,400 lbs. (3,810 kg) to geosynchronous transfer orbit.

The Delta III first stage is powered by an RS-27A main engine with two vernier engines used to control roll during main engine burn and also attitude between main engine cutoff (MECO) and first-stage separation. To enhance first-stage performance, the SLV uses nine 46-in. (1.17-m)-diameter Alliant Techsystems graphite-epoxy motors (GEMs), derived from those used on Delta II but which are larger and produce more thrust.

A Pratt & Whitney RL10B02 engine, which produces 24,750 lbs. (111,094 newtons) of thrust, powers the second stage. This engine, derived from the RL10 engine, has flown for more than 30 years. The second stage carries more propellant than the Delta II and burns cryogenic (cold) fuels, which produce more energy, allowing lift of heavier payloads.



Delta III Space Launch Vehicle

Delta III Major Events

Event	Time From Ignition (sec.)
Ignition	0
Maximum dynamic pressure	42
Jettison ground lit solid motors	83
Jettison air lit solid motors	162
Jettison fairing	226
Main engine cutoff	260
Second stage ignition	281
Second stage cutoff 1	762
Second stage restart	1307
Second stage cutoff 2	1510
Spacecraft separation	2174

The Delta III uses a 13.1-ft. (4-m)-diameter fairing that separates into halves in flight to permit satellite deployment. The payload is placed into the fairing before it is transported to the launch pad and integrated with the launch vehicle.

GOES-P and *GOES-Q* could be launched from Delta IV or Atlas III launch vehicles. The Atlas III is an improved version of the established Atlas II family of launch vehicles. The Atlas consists of a booster section, a



Atlas III Launch Vehicle

sustainer section, and an upper stage. It would be provided by Lockheed Martin Space Systems Company.

The GOES-NO/P/Q satellites will be launched from Cape Canaveral Air Force Station, Florida. They will be launched into a geosynchronous orbit approximately 22,240 statute miles (35,790 km) above the equator with an inclination angle of plus or minus 0.5° to the equator.

The GOES launch and orbit insertion sequence starts before liftoff with a buildup of thrust following Stage I engine ignition. Then hold-down bolts are fired and the launch vehicle lifts off. After clearing the launch pad, the launch vehicle climbs to its desired flight altitude and begins to pitch over in the trajectory phase. The solid strap-on engines are jettisoned at approximately 162 seconds after liftoff. The payload fairing is jettisoned from the launch vehicle at approximately 226 seconds. The control logic then provides a signal that cuts off the main engine and, 21 seconds later, ignites the second

stage. The second stage is shut down at 762 seconds and restarted at 1,307 seconds. Final second-stage cutoff (SECO) occurs at 1,510 seconds.

Orbit Terminology

Apogee - The part of an orbit where the spacecraft or launch vehicle is the farthest from the Earth.

Geostationary orbit - An orbit in which the satellite is always in the same position in relation to the Earth. It is approximately 22,240 miles (35,790 km) above the Earth's equator.

Liquid apogee motor - A motor that fires at apogee and at perigee to circularize the orbit. This motor uses liquid fuel.

Orbit raising - The sequence of events that maneuvers the spacecraft into its final orbit.

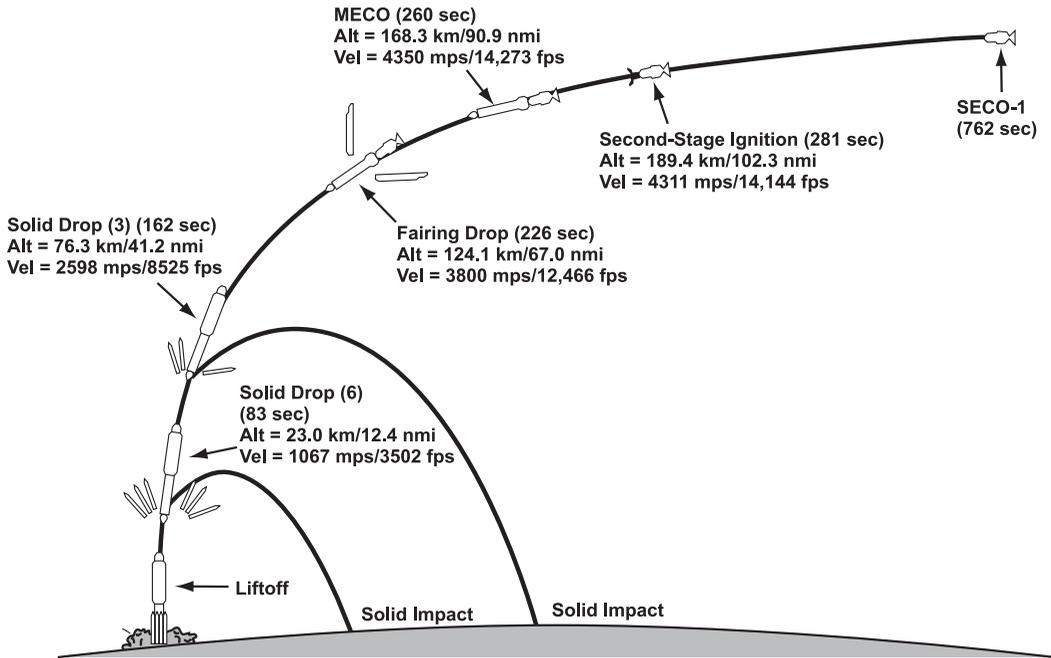
Perigee - The part of an orbit where the spacecraft or launch vehicle is closest to the Earth.

Supersynchronous transfer orbit - A temporary orbit whose apogee is farther away from the Earth than the final orbit.

Trajectory phase - The events that take place when the spacecraft is moving into its correct orbit.

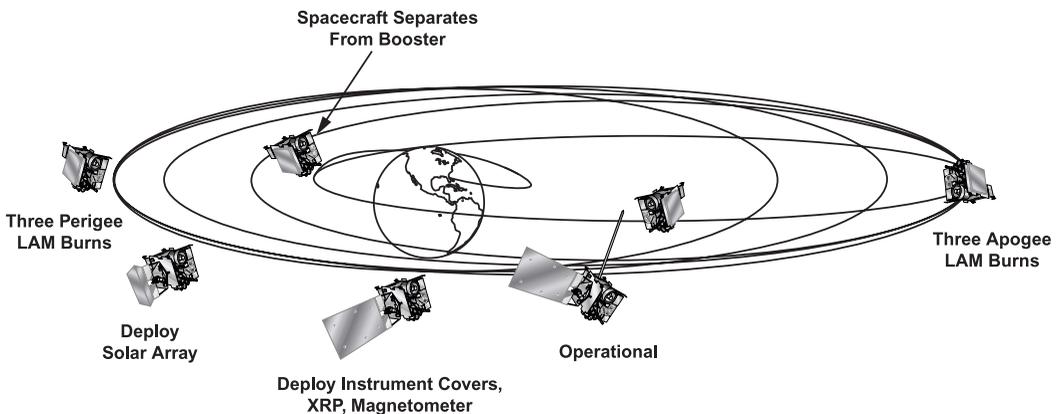
Transfer orbit - A temporary orbit that the spacecraft moves in before moving to its final position.

Transfer orbit phase - The part of the orbit lasting from the time when the spacecraft separates from the launch vehicle to the last perigee motor firing (the motor firing that occurs when the spacecraft is at its perigee, i.e., closest to the Earth).



Typical Delta III Geosynchronous Transfer Orbit Sequence (Times Are Approximate)

The spacecraft separates from its upper stage 36 minutes (2,174 seconds) after liftoff. The SLV then injects the spacecraft into a highly elliptical supersynchronous transfer orbit to begin the transfer orbit phase. A liquid apogee motor proceeds to place the spacecraft into the proper geostationary orbit through a sequence of several motor burns. The spacecraft arrives at its final location about 17 days after launch. During the test period that follows, thrusters are used to adjust the orbit.

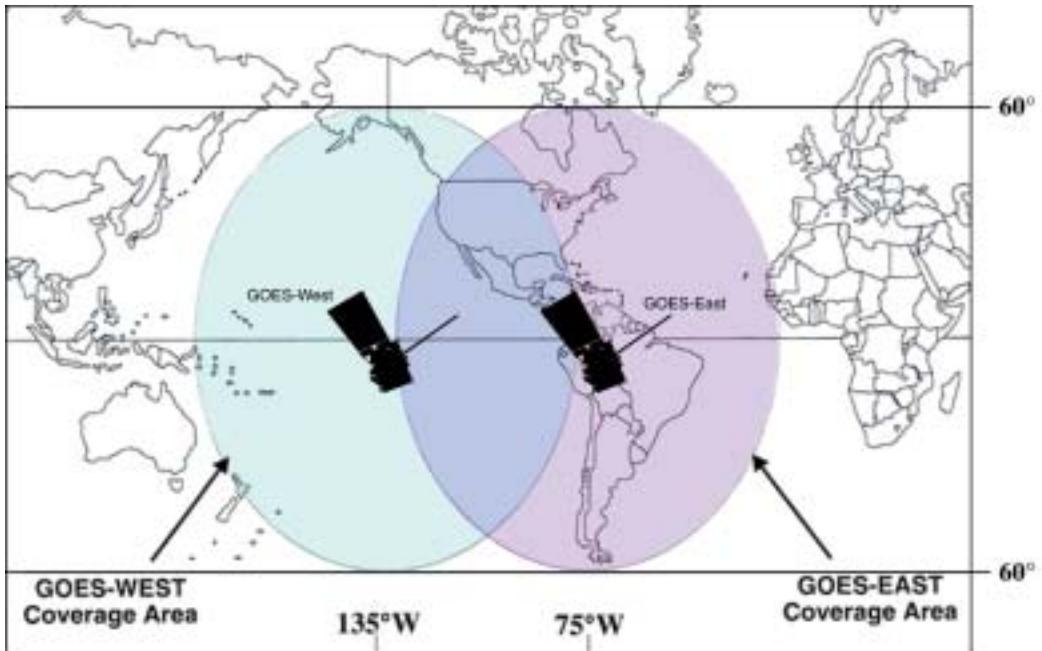


GOES Launch and Orbit-Raising Mission Phases

During the launch sequence and transfer orbits, near-continuous coverage is provided by telemetry and control stations at Wallops, Virginia; Goldstone, California; Madrid, Spain; and Canberra, Australia.

Normally, two GOES spacecraft operate concurrently. *GOES-East* is stationed at 75° west longitude, and *GOES-West* is located at 135° west longitude, both over the equator. *GOES-East* observes North and South America and the Atlantic Ocean. *GOES-West* observes North America and the Pacific Ocean to the west of Hawaii—the area often called “the birthplace of North American weather systems” by weather forecasters. Together, these satellites provide coverage for the central and eastern Pacific Ocean; North, Central, and South America; and the central and western Atlantic Ocean. The images that are produced from this hemispheric coverage and which are familiar to many television viewers are called “full-disk images,” such as the image on the cover of this brochure.

At least one GOES spacecraft is always within view of Earth-based terminals and ground stations within the western hemisphere. The command and data acquisition station (CDAS) can see both spacecraft so that it can transmit commands and receive data from each satellite simultaneously. Data collection platforms (DCPs) within the coverage area of each spacecraft can transmit their sensed surface-based data to the CDAS by means of the onboard data collection system (DCS). Ground terminals can also receive processed environmental data and EMWIN and LRIT/WEFAX transmissions.



GOES Coverage Area

Raw Imager and Sounder data received at the NOAA CDAS is processed in the spacecraft support ground system with other data to provide accurate, Earth-located, calibrated imagery and sounding data in near real time for uplink to the satellite and retransmission from the GOES spacecraft to primary end users, principally the seven National Weather Service field service stations located throughout the United States.

The GOES Image Navigation and Registration (INR) system ensures that Imager and Sounder data is consistent during the day by maintaining the pointing accuracy of the instruments. *Image navigation* is the process of determining the coordinates (Earth latitude and longitude) of each pixel within an image or sounding. *Image registration* is the process of maintaining the coordinates of each pixel within an image or sounding at the same Earth latitude and longitude independent of time.

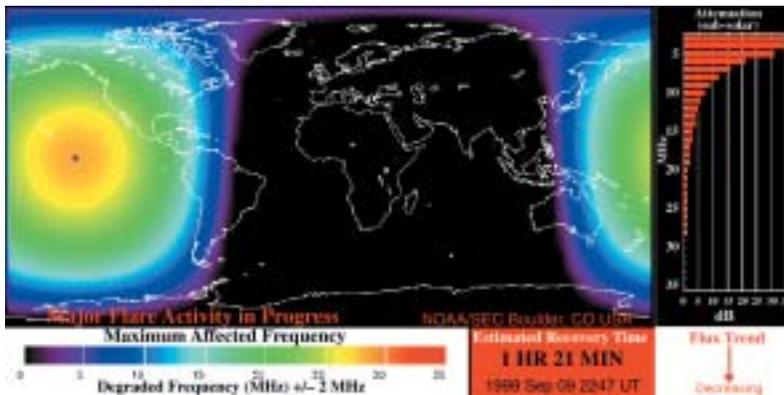
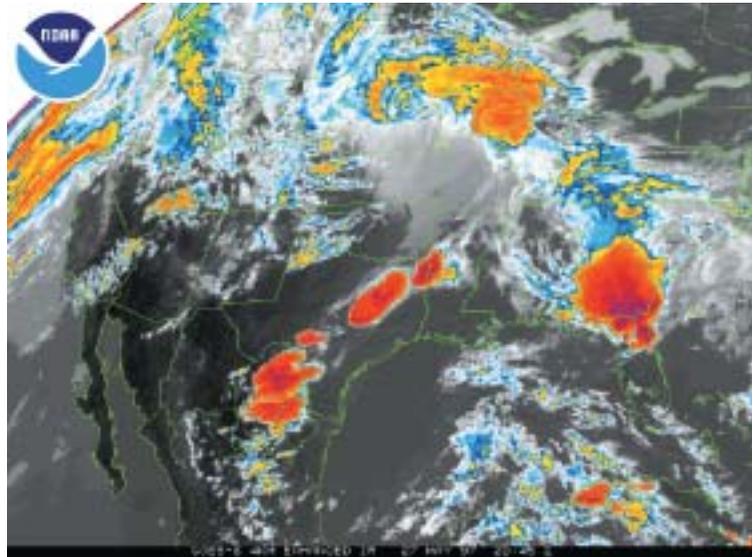
While in orbit, the spacecraft and consequently the instruments move slightly, which can cause the instruments to look at and scan slightly different areas of the Earth. Other conditions, such as vibrations, heat-related distortions, and erroneous signals to the instrument mirrors, can also lead to pointing inaccuracies that can produce inconsistent data. The INR system continuously adjusts the aim of the instruments' scan mirrors to compensate for the motion of the spacecraft and other disturbances. The system uses image landmarks, star views, and satellite range data collected throughout the day to make the adjustments.

INR Performance Requirements

		Microradians (μ rad)	Kilometers (km)
IMAGER			
0	Imager navigation accuracy	56	2
0	Registration within an image	42	1.5
0	Registration between repeated images		
	15 minutes	28	1
	90 minutes	42	1.5
	24 hours	112	4
0	Channel-to-channel registration	28	1
SOUNDER			
0	Earth location accuracy	280	10
0	Registration within 120-minute sounding	84	3
0	Registration between repeated soundings		
	90 minutes	84	3
	24 hours	224	8

GOES instruments generate many data products and provide several services to the science community, meteorologists, and the public. These include the commonly seen images produced by the Imager and Sounder; data from the SEM that is transmitted to and processed by the SEC in Boulder, Colorado; information gathered by data collection platforms; text, images, and graphics transmitted by EMWIN; data transmitted through the LRIT/WEFAX system; and search and rescue services. A sample of images generated by the Imager and Sounder and from SEM data appears below and on the pages that follow. For additional data products and images, see the *GOES Products and Services Catalog* published by the National Environmental Satellite, Data, and Information Service (NESDIS) at <http://orbit-net.nesdis.gov/arad/fpdt/goescat> and at <http://osdaccs.nesdis.noaa.gov:8081/satprod/>.

This image shows the Jarrell, Texas, tornado event on May 27, 1997. The red areas are clouds with severe storm activity. The image does not distinguish between tornado activity and other severe storms. Radar and other ground data are needed to provide that additional information.

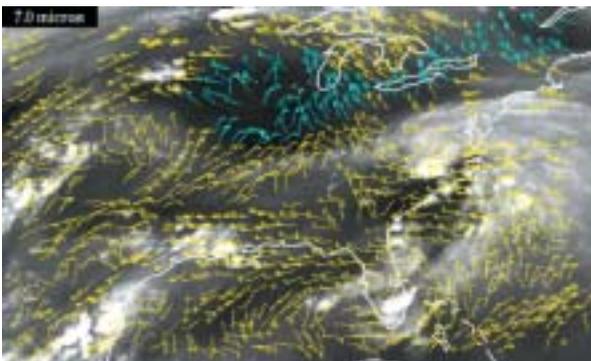
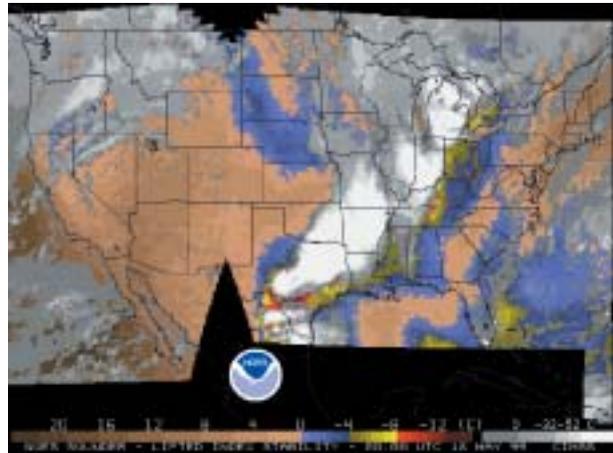


Absorption of high-frequency radio waves in the D-Region of the ionosphere (the lowest layer of the ionosphere) is directly affected by the level of solar x-ray flux. The D-Region absorption product was developed to assist high-frequency radio operators and is based entirely on real-time data from the x-ray sensor.

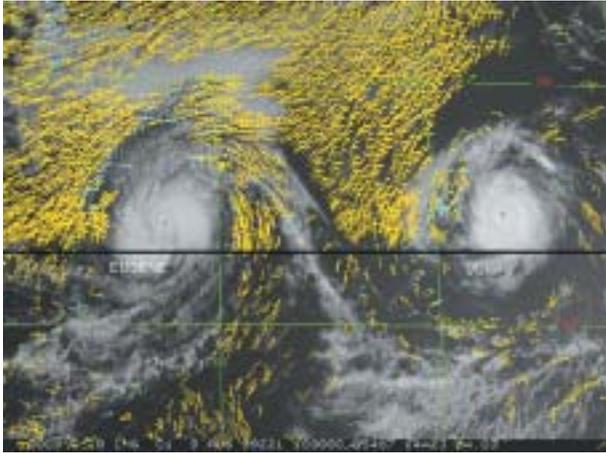


This Sounder-derived image shows the tornado event that occurred near Jarrell, Texas, on May 27, 1997. The numbers, called a lifted index, represent atmospheric stability. The more negative numbers indicate a more unstable atmosphere. A -10 or lower is considered very unstable—a breeding ground for tornadoes and other severe storms. On this map, the most unstable area is bordered in red, where lifted index numbers fall as low as -16 and where the tornado later broke out.

This image, also derived from Sounder data, shows the degree of stability in the atmosphere as expressed in a lifted index scale that is color-coded at the bottom of the image. The red areas of the map in eastern Texas correspond to quite negative lifted index values. They are the most unstable, with serious potential for tornadoes or other severe storm activity. The beige areas of the map show positive lifted index values. They indicate stable conditions over the southwestern states.



Wind data is derived from the GOES Sounder's water vapor channels in the mid-troposphere, the level of the atmosphere where the jet stream develops and carries weather systems. The straight end of a wind barb points in the direction that the wind is blowing. The density of a barb's tail shows the intensity of the wind. The color of a barb shows its altitude.



This image shows low-level visible cloud-drift winds around hurricanes Eugene and Dora. Three 15-minute sectors (above the horizontal black line) and three 30-minute sectors (below the black line) were used to derive the visible winds from Imager data. Note the significant improvement in detail of the wind field from data that was obtained in 15-minute intervals in the top half of the image. The straight end of each wind barb points in the direction that the wind is blowing.

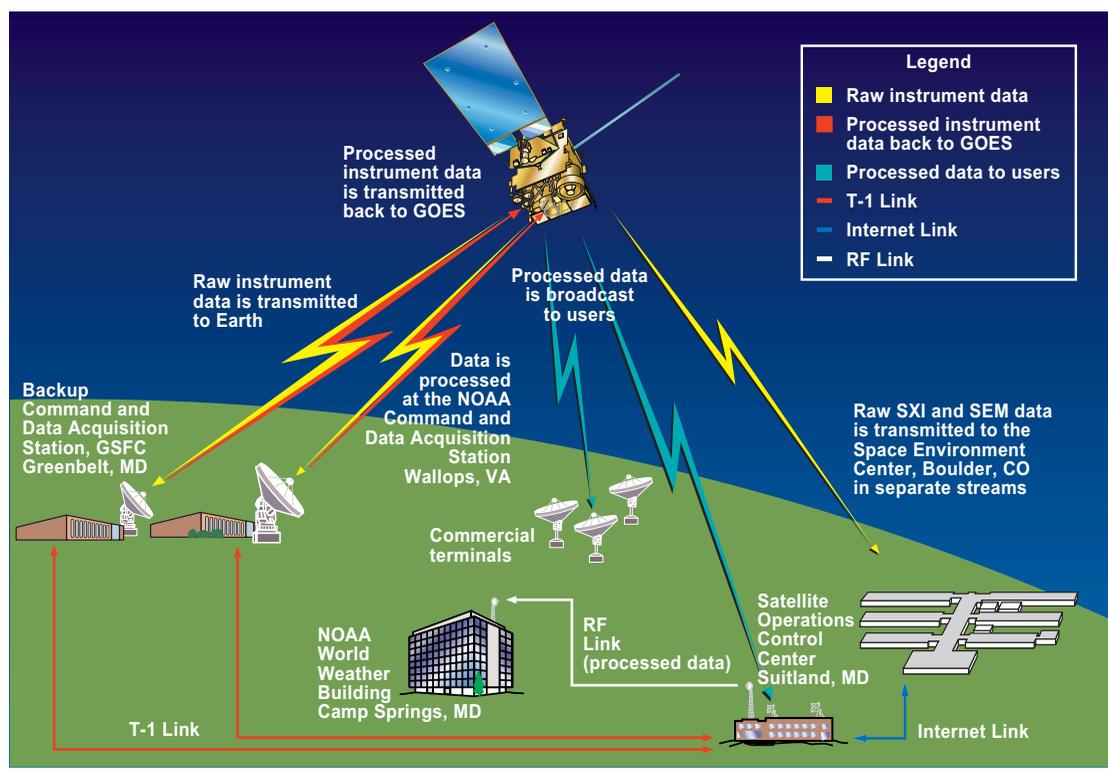
This image of Hurricane Floyd was taken on September 15, 1999, from a color combination of GOES visible channel 1 and infrared channels 2 and 4. This color combination presents high clouds as white, low clouds as yellow (such as in the eye of the hurricane), and the ocean as dark blue.



Several fires in northeastern Florida are seen in this image, a color combination of GOES visible channel 1 and infrared channels 2 and 4. Smoke from the fires appears as low (yellow) haze that stretches eastward from northern Florida out over the Atlantic Ocean.

The GOES communications subsystem consists of the antennas and transponders that allow GOES to receive and transmit data. This includes raw instrument data transmitted to the ground, processed instrument data that is received on the spacecraft and then retransmitted to ground users, search and rescue data, weather data sent by the LRIT/WEFAX service, reports from the data collection platforms (DCPs), and the wide range of data transmitted by the Emergency Managers Weather Information Network (EMWIN).

The communication antennas on the spacecraft are mounted on the panel that faces the Earth. They send and receive data from the ground stations located within the GOES coverage area. Particular types of antennas, called L-band, S-band, and UHF (ultra-high frequency) antennas, provide communications for specific purposes. Some transmit data from the spacecraft to the ground (called downlink) while others transmit data from the ground to the spacecraft (uplink). For instance, an L-band antenna downlinks search and rescue data from the spacecraft to the ground while the UHF antenna receives search and rescue data and data from the DCPs. Additional antennas also receive data that is used to control the spacecraft and instruments.



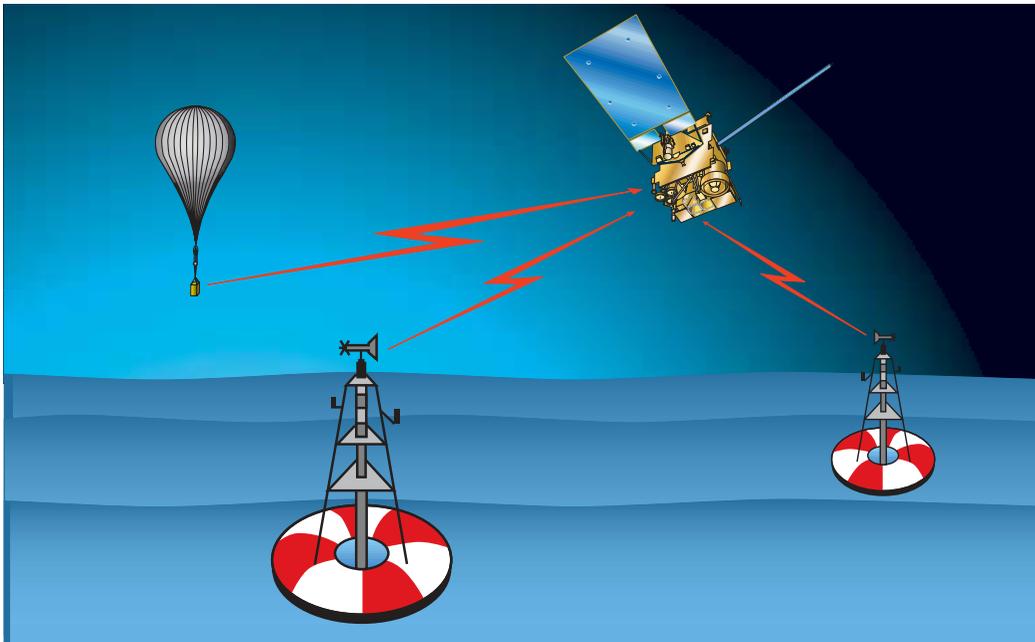
GOES Communications System (Simplified)

Sensor Data

After the raw Imager and Sounder data is processed on the ground, the processed data is uplinked to the spacecraft. This processed data is then downlinked to the Satellite Operations Control Center (SOCC) at Suitland, Maryland, and transmitted to the World Weather Building at Camp Springs, Maryland, for subsequent distribution to data users, who typically are staff of satellite field service stations located throughout the United States. The SOCC also receives diagnostic data that describes the performance of the Imager and Sounder on the multi-data downlink.

Data Collection System

The Data Collection System (DCS) is a communications relay system that handles information gathered from more than 19,000 data collection platforms located in remote areas. The platforms consist of buoys, free-floating balloons, and weather stations. Sensors on the platforms measure environmental factors such as atmospheric temperature and pressure and the velocity and direction of the ocean and wind currents. The DCS transponder on board the spacecraft collects these measurements and provides near real-time relay of environmental data for centralized archiving and distribution. The digital data is used to develop analyses of environmental events such as tsunamis, tropical cyclones, and floods and to map river stages, soil conditions, and snow depth.



Data Collection System

LRIT/WEFAX

The digital Low Rate Information Transmission (LRIT) data originates from the National Weather Service and from NOAA image-processing facilities. The LRIT digital WEFAX products will be similar to the current analog service and is planned to improve the quality of the current WEFAX products. The LRIT is an international standard for data transmission that is supported by all operational geostationary meteorological satellites flown by the United States, European agencies, Japan, China, and Russia. This system can contain significantly more meteorological data, imagery, charts, and other environmental information than the current WEFAX system.

Emergency Managers Weather Information Network

The EMWIN data service became operational in June 1996. It transmits more than 50,000 pages of text, images, and graphics each day to more than 10,000 users in 35 countries. The service transmits simple, reliable, and affordable data continuously to its data user community.

Command and Data Acquisition

The primary command and data acquisition station (CDAS) is located at Wallops, Virginia. A NOAA backup CDAS is located at NASA's Goddard Space Flight Center (GSFC) in Greenbelt, Maryland. This backup station, which became operational in September 2000, normally operates in a standby mode. If the primary station at Wallops is threatened or hit by a hurricane, the backup station becomes operational and takes over command and data acquisition functions—ensuring that data from *GOES-East* or *GOES-West* will continue to flow. There are three new 54-ft. (16.4-m)- antennas, two at Wallops and one at GSFC, which are designed to operate through a Category 3 hurricane (130 miles per hour) (209 km/hr) and can survive a Category 5 hurricane (155+ miles per hour) (249+ km/hr).



***16.4-Meter Backup Antenna at
Goddard Space Flight Center***

The CDAS carries out command and data acquisition and processed data relay functions for the GOES program. It transmits commands to the operational satellites and acquires and records instrument and engineering data received from the satellites. Raw instrument data is processed at the CDAS. The processed data is then transmitted to the satellites for re-broadcast to users.

NOAA and NASA are actively engaged in a cooperative program to continue the GOES system with the launch of the GOES NO/P/Q satellites. Since 1974, the two partners have worked together to develop, perfect, and operate the GOES program. The current GOES spacecraft are a key element in NOAA's National Weather Service modernization program.

NASA's GSFC procures, develops, and tests the spacecraft, instruments, and unique ground equipment. Following deployment of the spacecraft from the launch vehicle, GSFC is responsible for the mission operations phase leading to the injection of the satellite into geostationary orbit and initial on-orbit satellite checkout and evaluation.

NOAA is responsible for program funding and the on-orbit operation of the system. NOAA also determines the need for satellite replacement. NESDIS is the arm of NOAA that operates the GOES system. It is responsible for implementing, operating, and maintaining the SOCC facility at Suitland, Maryland; the CDAS at Wallops, Virginia; and the command and data acquisition backup station at GSFC in Greenbelt, Maryland.

NOAA is also responsible for processing, analyzing, disseminating, and archiving all operational data, which is available to government researchers and others for research and environmental applications. NOAA's Central Data and Distribution Facility (CDDF) at the World Weather Building in Camp Springs, Maryland, and the Space Environment Center, along with the National Geophysical Data Center (NGDC), in Boulder, Colorado, disseminate the data.

NOAA and NASA jointly design, develop, install, and integrate the ground system needed to acquire, process, and disseminate the data from the satellite sensors.

NASA Support Facilities

The NASA Integrated Services Network (NISN) (formerly NASCOM) provides voice and communications data circuits during prelaunch, launch, and postlaunch activity. NASA's Kennedy Space Center is responsible for providing support for contractor-provided launch services.

NOAA Support Facilities

The **Satellite Operations Control Center (SOCC)** is located at Suitland, Maryland. The SOCC is used as the focal point during the GOES launch operations activity. The SOCC is responsible for obtaining necessary satellite data in real time, processing this data for display and analysis, and performing satellite command operations and mission scheduling. The SOCC also supports the operational phase of the mission after satellite handover to NOAA.

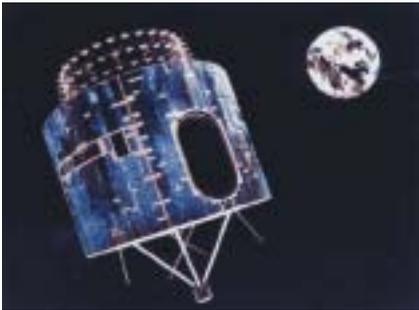
The **Space Environment Center** at Boulder, Colorado, receives, processes, and validates data from the SEM and SXI that is used for real-time space weather operations and prepared for archives that are located at the NGDC.

Launch Support

The Deep Space Network (DSN), which is maintained and operated by the Jet Propulsion Laboratory (JPL), supports the launch of GOES spacecraft. DSN tracking stations are located at Madrid, Spain; Canberra, Australia; and Goldstone, California. Additional launch support is provided by NOAA and NASA facilities at Wallops, Virginia, and Merritt Island, Florida.

GOES History

SMS-1 (SMS-A) was launched on May 17, 1974, from the Eastern Test Range (ETR) at Cape Canaveral, Florida. It was the first geostationary meteorological satellite. Launched from a Delta



Composite Photo Showing the On-Station Position of SMS-1 in 1974

2914 space launch vehicle, its objectives were to evaluate a prototype operational meteorological satellite for NOAA's National Weather Service and provide regular daytime and nighttime meteorological observations in support of the national operational meteorological satellite system. The principal instrument on board was the Visible/Infrared Spin Scan Radiometer (VISSR), which provided day and night imagery of cloud conditions. The satellite was also equipped with a SEM and a DCS. The satellite also had the capability to perform facsimile transmissions of processed images and weather maps to WEFAX field stations. The satellite was positioned in a geostationary orbit directly over the

equator at 45° W (over the central Atlantic), which provided continuous coverage of the central and eastern United States and the Atlantic Ocean. It was operational until January 1976 and was deactivated and boosted out of orbit on January 21, 1981.

SMS-2 (SMS-B) was launched February 6, 1975, from a Delta 2914 space launch vehicle. It was equipped with a VISRR, SEM, and DCS and had WEFAX capability. It was placed in a geostationary orbit directly over the equator at 135° W (over the east-central Pacific Ocean). The satellite was deactivated August 5, 1982. SMS-1 and SMS-2 proved the viability of geosynchronous meteorological satellites.

GOES-1 (GOES-A) was the first in the series of Geostationary Operational Environmental Satellites. It was launched from a Delta 2914 launch vehicle on October 16, 1975. Its instrument complement was



SMS-B Erected Atop Its Delta Booster, 1975



GOES-1 Image, October 25, 1975

identical to SMS-1 and SMS-2. GOES-1 was placed over the Indian Ocean west of SMS-2 so that the combined coverage of the three satellites would include nearly 60 percent of the Earth's surface. It operated successfully in this orbit until June 1978 when it was relocated to replace SMS-2 and GOES-3 replaced GOES-1. It was deactivated on March 7, 1985.

GOES-2 (GOES-B) was launched on June 16, 1977, from a Delta 2914 launch vehicle. Its instrument complement was identical to the SMS and GOES-1 satellites. GOES-2 was placed in orbit directly over the equator at 60° W to replace SMS-1. It was operational until 1993. The satellite was reactivated in 1995 to broadcast National Science Foundation

(NSF) transmissions from the South Pole to public broadcasting facilities in the United States. The WEFAX system on GOES-2 continued to operate, although cloud images were no longer being received from the system. The satellite was deorbited at the beginning of May 2001.

GOES-3 (GOES-C) was launched June 16, 1978, from a Delta 2914 launch vehicle. The satellite was used to replace GOES-1 and to support the Global Atmospheric Research Program (GARP) over the Indian Ocean. It had the same instruments and capabilities as the earlier GOES spacecraft. GOES-3 is currently being used by the University of Miami for communications purposes.

GOES-4 (GOES-D) was launched September 9, 1980, from a Delta 3914 launch vehicle. It was the first geostationary satellite to provide continuous vertical profiles of atmospheric temperature and moisture, which its primary instrument, the VISSR Atmospheric Sounder (VAS), provided. The VAS also provided both day and nighttime imagery of cloud conditions. Instrument limitations did not permit both types of operations simultaneously. The satellite also used new despun S-band and UHF antennas to relay meteorological data from more than 10,000 surface locations into a central processing center for incorporation into numerical weather prediction models and to transmit processed images and weather maps to WEFAX field stations. It was also equipped with a SEM and DCS similar to those on previous GOES. GOES-4 was placed in orbit at 135° W to replace the failing GOES-3. GOES-4's most serious anomaly occurred on November 25, 1982, when the VAS's scan mirror stopped during retrace after exhibiting excessively high torque. Efforts to restore either the visible or infrared capabilities were unsuccessful. It was deactivated November 22, 1988.

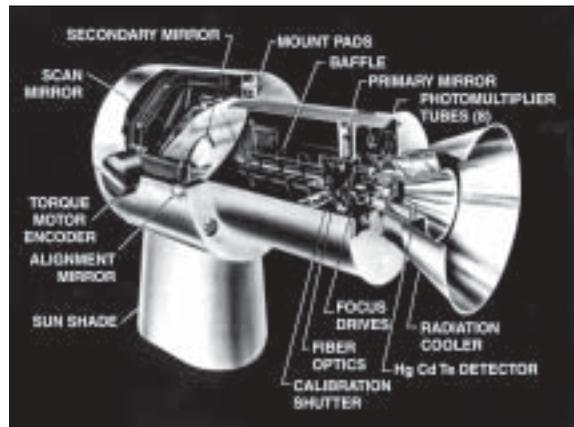
When satellites are launched, they have a letter designation. After they reach orbit, they are assigned a number. This prevents a missing number if a spacecraft does not reach orbit successfully.

GOES-5 (GOES-E) was launched May 22, 1981, from a Delta 3914 launch vehicle. Its instrument complement was identical to GOES-4. It was placed in orbit at 75° W longitude. The satellite failed on July 29, 1984, when a VAS encoder lamp filament burned out that was needed to read the angle of the scan mirror used to obtain images. It was deactivated on July 18, 1990.

GOES-6 (GOES-F) was launched April 28, 1983, from a Delta 3914 launch vehicle. It was designed to replace GOES-4 and was originally placed in orbit at 136° W. After GOES-5 failed, it was moved to a central location at 98° W. When GOES-7 was placed in service, it was returned to its original location. The VAS imager on GOES-6 failed on January 21, 1989, so direct read-out images and soundings were no longer available. WEFAX data continued to be transmitted to the data user community until the spacecraft was deactivated on May 24, 1992.

GOES-G was launched May 3, 1986, from a Delta 3914 launch vehicle. The spacecraft did not reach operational orbit because of a failure in the launch vehicle.

GOES-7 (GOES-H) was launched February 26, 1987, from a Delta 3924 launch vehicle and placed in orbit at 75° W. The spacecraft was moved to 98° W in July 1989 following the January 1989 failure of GOES-6. In 1992, GOES-7 ran out of stationkeeping fuel, as expected. GOES-7 went to standby in January 1996 and was parked at 95° W in June 1996. Consequently, the VAS instrument and the associated data, along with WEFAX, DCS, and search and rescue services through GOES-7, were deactivated. In mid-November 1999, GOES-7 was moved to 175° W to take over the communications-relay duties of PEACESAT. The high orbital inclination made it possible to relay data from near the poles, particularly to support the National Science Foundation science group at the South Pole. In addition to the same instrument complement as the earlier GOES, GOES-7 carried experimental search and rescue equipment that allowed near-instantaneous detection of emergency distress signals on the ground transmitting at 406 MHz.



VAS Was Found on GOES-4 Through GOES-7

GOES-8 (GOES-I) was launched April 13, 1994, from an Atlas-I/Centaur launch vehicle. In 2001, it is operational as *GOES-East* at 75° W. It was the first in a new series of three-axis stabilized GOES that provided significant improvements over the previous GOES spin-stabilized spacecraft in weather imagery and atmospheric sounding information. The satellite is equipped with a separate Imager and Sounder, which allows simultaneous and independent imaging and sounding. Previously, both functions were performed alternately by a single instrument. GOES-8 features a flexible scan mechanism that offers small-scale area imaging, resulting in improved

short-term forecasts over local areas. It is also equipped with a SEM and DCS, has WEFAX capabilities, and performs near-instantaneous relay functions for the Sarsat system with its dedicated search and rescue transponder.

GOES-9 (GOES-J) was launched May 23, 1995, from an Atlas-I/Centaur launch vehicle into a geostationary orbit at 135° W. It was deactivated on July 28, 1998, because of failing bearings in the momentum wheels and is in storage.



Hurricane Bret, 1999

GOES-10 (GOES-K) was launched April 25, 1997, from an Atlas I/Centaur launch vehicle and was placed in orbit at 105° W. It has the same instrument complement as GOES-8 and GOES-9. In the spring of 1998, GOES-10 was shut down and designated an “on-orbit spare” until the failure of GOES-8 or GOES-9. A month after launch, the GOES-10 solar array ceased rotating, but, due to the ingenuity of the GOES government-industry team, it was possible to invert the satellite, modify software, and operate the solar array in the reverse direction. Shortly thereafter, GOES-9 began experiencing problems with its momentum wheels, and GOES-10 was placed in active service as *GOES-West*, positioned at 135° W.

GOES-11 (GOES-L) was launched May 3, 2000, from an Atlas Centaur IIA launch vehicle and placed in storage mode at 105° W in August 2000. It has the same instrument complement as GOES-8, 9, and 10.

GOES-12 (GOES-M) was launched July 23, 2001, from an Atlas Centaur IIA launch vehicle. It is the first GOES to fly an SXI-type instrument.

GOES Spacecraft Contractors

The SMS and GOES 1-3 spacecraft were built by Ford Aerospace and Communications Corporation (now Space Systems/Loral). The GOES 4-7 series was built by Hughes Space and Communications (now Boeing Satellite Systems). The GOES 8-12 series was built by Space Systems/Loral. GOES-NO/P/Q are being built by Boeing Satellite Systems.

As well as the web sites mentioned elsewhere in this brochure, see <http://www.oso.noaa.gov/goes/index.htm>, <http://goes2.gsfc.nasa.gov>, and <http://rsd.gsfc.nasa.gov/goes> for additional information on the GOES program and GOES science. For additional copies of this brochure, please write to: GOES Program Manager, NASA Goddard Space Flight Center, Mail Code 415, Greenbelt, MD 20771.

Acronyms and Abbreviations

µm	micrometer	LRIT	Low Rate Information Transmission
µrad	microradian	LUT	Local User Terminal
AFB	Air Force Base	m	meter
Alt	altitude	MAGED	Magnetosphere Electron Detector
CCD	Charge Coupled Device	MAGPD	Magnetosphere Proton Detector
CDAS	Command and Data Acquisition Station	MCC	Mission Control Center
CDDF	Central Data and Distribution Facility	MECO	Main engine cutoff
COSPAS	<i>Cosmicheskaya Sistyema Poiska Avariynich Sudov</i> (Space System for the Search of Vessels in Distress)	MeV	Million electron volts
CSPA	Charge Sensitive Preamplifier	MHz	Megahertz
DCP	Data collection platform	MLI	Multilayer insulation
DCS	Data collection system	mps	meters per second
DPU	Data processing unit	NASA	National Aeronautics and Space Administration
DSN	Deep Space Network	NASCOM	NASA Communications (Network)
ELT	Emergency Locator Transmitter	NGDC	National Geophysical Data Center
EMWIN	Emergency Managers Weather Information Network	NiH ₂	Nickel hydrogen
EPEAD	Energetic Proton, Electron, and Alpha Detector	NISN	NASA Integrated Services Network
EPIRB	Emergency Position Indicating Radio Beacon	nm	nanometer (one-billionth of a meter)
EPS	Energetic Particle Sensor	nmi	nautical mile
ER	Eastern Range	NSF	National Science Foundation
ETR	Eastern Test Range	NESDIS	National Environmental Satellite, Data, and Information Service
EUV	Extreme ultraviolet	NOAA	National Oceanic and Atmospheric Administration
eV	Electron volt	OSR	Optical solar reflector
FOV	Field of view	PLB	Personal Locator Beacon
fps	feet per second	PMT	Photo Multiplier Tube
ft	feet, foot	PSS	Precision Sun Sensor
GARP	Global Atmospheric Research Program	RCC	Rescue Coordination Center
GEM	Graphite epoxy motor	RSC	Rescue Sub-Center
GOES	Geostationary Operational Environmental Satellite	RF	Radio frequency
GPS	Global Positioning System	SAIC	Science Applications International Corporation
GSFC	Goddard Space Flight Center	SARSAT	Search and Rescue Satellite-Aided Tracking
HASS	High Accuracy Sun Sensor	SEC	Space Environment Center
HEPAD	High Energy Proton and Alpha Detector	sec	second
HV	High voltage	SECO	Second Engine Cutoff
Hz	hertz	SEM	Space Environment Monitor
in	inch	SLV	Space Launch Vehicle
INR	Image Navigation and Registration	SMS	Synchronous Meteorological Satellite
ITT A/CD	ITT Aerospace/Communications Division	SOCC	Satellite Operations Control Center
JPL	Jet Propulsion Laboratory	SSD	Solid State Detector
keV	kilo (thousand) electron volts	SXI	Solar X-Ray Imager
kg	kilogram	UHF	Ultra high frequency
kHz	kilohertz	USMCC	U.S. Mission Control Center
km	kilometer	VAS	VISSR/Atmospheric Sounder
kW	kilowatt	Vel	velocity
LAM	Liquid apogee motor	VISSR	Visible Infrared Spin Scan Radiometer
lb	pound	WEFAX	Weather Facsimile
LMATC	Lockheed Martin Advanced Technology Center	XRP	X-ray positioner
		XRS	X-ray sensor

