

8. Communications Subsystem

The spacecraft communications subsystem provides requisite conditioning, transmission, reception, and routing of mission data signals and telemetry for the GOES space segment. It consists of eight major component groups that serve the following variety of functions:

- Imager and Sounder sensor data (SD) modulation and transmission
- Processed data relay (PDR)
- Weather facsimile (WEFAX/LRIT) relay
- Emergency managers weather information network (EMWIN) relay
- Multiuse data link (MDL) modulation and transmission
- Data collection platform interrogate (DCPI) relay
- Data collection platform report (DCPR) relay
- Search and rescue (SAR) data relay

Four antennas, each with full earth coverage beamwidth, support communications with the ground segment:

- S-band receive and L-band transmit cup-dipole
 - Receives the PDR, WEFAX/LRIT, EMWIN, and DCPI S-band uplink signals
 - Transmits the WEFAX/LRIT, MDL, and DCPR L-band downlink signals
- L-band transmit cup-dipole—transmits SD, PDR, and EMWIN L-band downlink signals
- UHF receive and transmit cup-dipole
 - Receives DCPR and SAR signals
 - Transmits DCPI signal
- L-band transmit cup-dipole: transmits SAR downlink signal

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The subsystem is configured as shown in Figure 8-1. Multiplexers are used to interface multiple signals with low RF loss into and/or out of an antenna. The two L-band output multiplexers and the UHF diplexer filter and separate the uplinks from the downlinks while combining the various transmit signals for the composite downlinks. The SAR transmit signal uses a single output filter. The output filtering also rejects unwanted out-of-band signals and harmonics. On the receive side, low noise amplification, frequency translation and channel filtering are within the S-band and UHF receivers. The channel filters separate the uplink signals—S-band: PDR, WEFAX/LRIT, EMWIN, DCPI; and UHF: DCPR, SAR—for subsequent frequency translation and high power amplification by their respective individual SSPAs. The DCPR and WEFAX/LRIT use linear SSPA amplification. The other services—SD, PDR, EMWIN, MDL, DCPI—use nonlinear SSPA amplification.

Space-Ground Communications Interfaces

The flexibility and multitude of services provided by the GOES spacecraft are functions of the communication interfaces between the spacecraft and ground, as are shown in Figure 8-2. The major system interfaces are those linking GOES N-P to the command

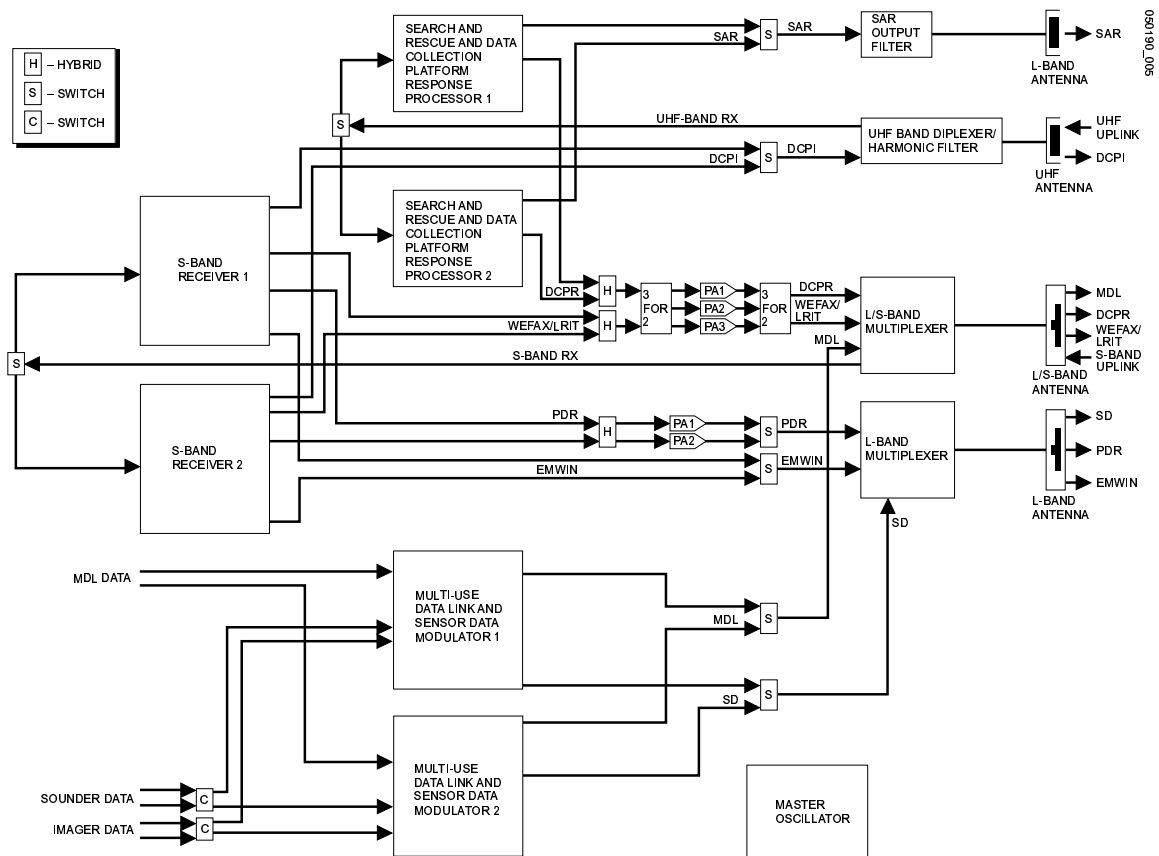
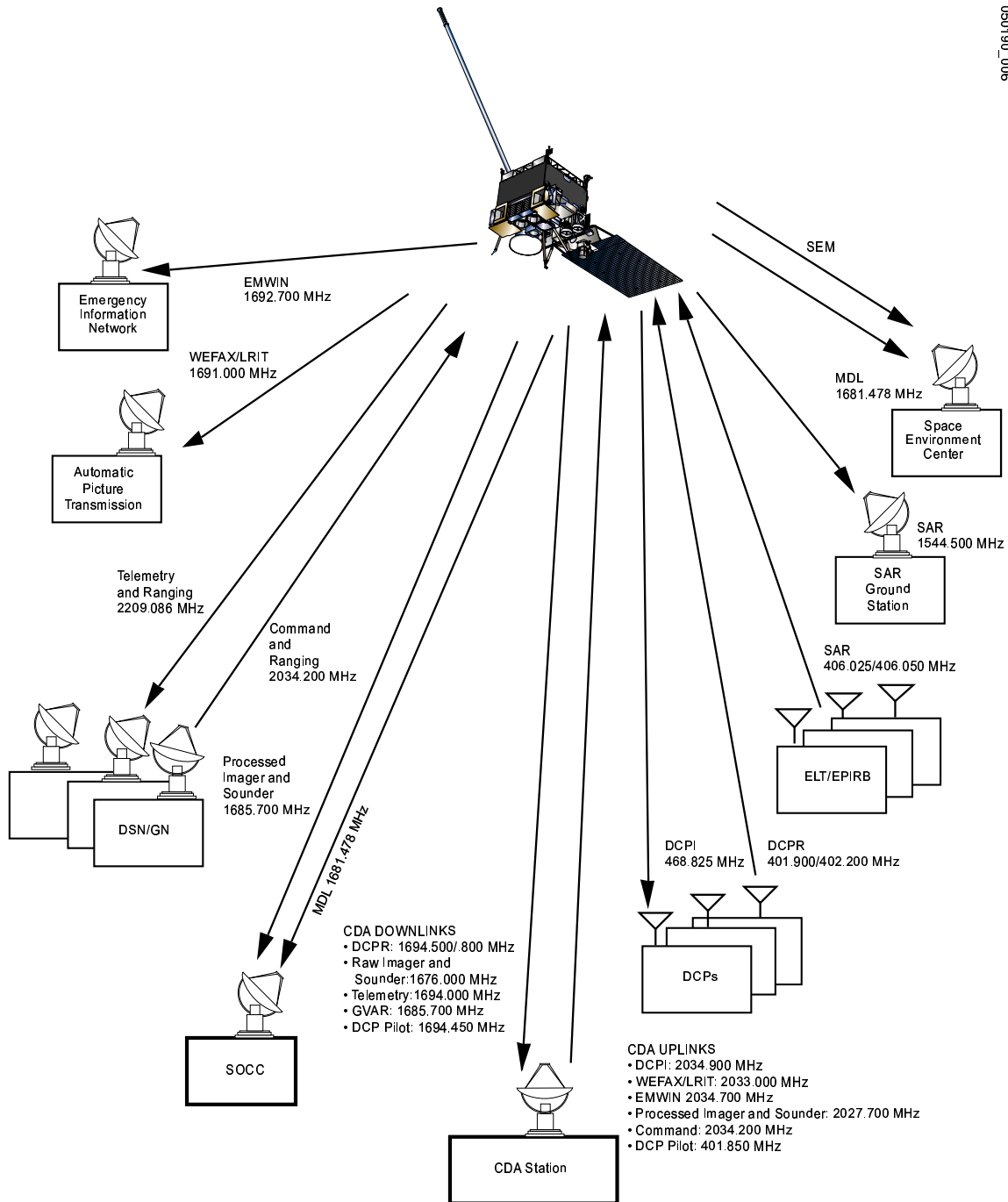


Figure 8-1. Communications Subsystem Configuration

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Legend

| | | | |
|-------|--|------------|-------------------------------------|
| CDA | Command and Data Acquisition | GN | Ground Network |
| DCP | Data Collection Platform | GVAR | GOES Variable Data |
| DCPI | Data Collection Platform Interrogate | MDL | Multise Data Link |
| DCPR | Data Collection Platform Report | SAR | Search and Rescue |
| DSN | Deep Space Network | SEM | Space Environment Monitor |
| ELT | Emergency Locator Transmitter | SOCC | Satellite Operations Control Center |
| EMWIN | Emergency Managers Weather Information Network | WEFAX/LRIT | Weather Facsimile |
| EPIRB | Emergency Position Indicator Response Beacon | | |

Figure 8-2. Space-ground Communications Interfaces

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and control ground stations, end user equipment, and communications service terminals. The principal interfaces are those between the spacecraft and the command and data acquisition (CDA) station, namely:

- CDA downlinks
 - Raw Imager and Sounder data
 - Data collection platform report
 - MDL data
 - Spacecraft telemetry
- CDA uplinks
 - Processed Imager and Sounder data (GVAR)
 - Data collection platform interrogation
 - Weather facsimile transmission/Low Rate Information Transmission
 - Emergency managers weather information network transmission
 - Spacecraft commands

Data Links

The space environment data are downlinked to the end user at the Space Environment Center in Boulder, Colorado, on the Multi-Use Data Link (MDL). The processed Imager and Sounder (calibrated, earth-located) data are downlinked to the Satellite Operations Control Center (SOCC) at Suitland, Maryland, then to the World Weather Building for subsequent distribution to end users, who are typically personnel manning satellite field forecast offices located throughout the United States. The processed data are also received directly by other Government and commercial users in the United States and other countries within view of the GOES satellites. The SOCC also receives diagnostic data from the MDL for further analysis.

Weather Facsimile Transmission/Low Rate Information Transmission (WEFAX/LRIT)

In 1991, the Coordinating Group for Meteorological Satellites (CGMS) began discussing the possible replacement of the current international standard for analog Weather Facsimile (WEFAX) Broadcast Services from geostationary meteorological satellites.

In July 1998, the LRIT global specifications were approved by the United States (NOAA), Europe (EUMETSAT), Japan (JMA/NASDA), China (CMA/SMC), and Russia (Planeta). Also, all participants at the meeting, except for the United States, committed to a specific planning date for implementing the LRIT requirements.

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In 1999, NOAA announced its plans to implement the LRIT format. The GOES-N series will manifest a complete transition to a new service. The new digital WEFAX/LRIT service is a combination of several information sources onto a single higher capacity broadcast (128 kbps) that contains significantly more meteorological data, imagery, charts and other environmental information.

Emergency Managers Weather Information Network Transmission

The emergency managers weather information network (EMWIN) transmission is a communication service provided through a transponder onboard the GOES satellite. EMWIN is a suite of data access methods that make available a live stream of weather and other critical emergency information. Each method has unique advantages. EMWIN's present methods in use or under development for disseminating the basic data stream include radio, Internet, and satellites (GOES and commercial satellites). As an integral part of its mission, the National Weather Service (NWS) recognizes the need to provide the emergency management community with access to a set of NWS warnings, watches, forecasts, and other products. In partnership with the Federal Emergency Management Agency (FEMA) and other public and private organizations, EMWIN is now evolving into a fully operational and supported NWS service.

Data Collection System

The GOES data collection system (DCS) collects near real-time environmental data from data collection platforms (DCPs) located in remote areas where normal monitoring is not practical. The DCS receives data from DCPs on aircraft, ships, balloons, and fixed sites in a region from Antarctica to Greenland and from the west coast of Africa to just east of the Hawaiian Islands, an area covered by the GOES satellites. The system encompasses almost every level of the atmosphere, land, and ocean. It is used to monitor seismic events, volcanoes, tsunamis, snow conditions, rivers, lakes, reservoirs, ice cover, ocean data, forest fire control, meteorological and upper air parameters, and to provide ground truth information. The GOES N-P satellite is compatible with the new data collection platform that have data transmission rates of 300 bps and 1200 bps and is also compatible with the older data collection platforms that have a data rate at 100 bps. On GOES satellites prior to N-P, only a small number of 300 and 1200 bps transmitters could be accommodated.

Search and Rescue

The search and rescue (SAR) subsystem onboard each GOES satellite is a dedicated transponder that relays the distress signals broadcast by UHF emergency locator transmitters (ELTs) carried on general aviation aircraft, emergency position indicating radio beacons (EPIRBs) aboard some classes of marine vessels, and portable personal locator beacons (PLBs). The SAR mission is performed by relaying the distress signals emitted from the ELT/EPIRBs via the GOES satellite to a Local User Terminal (LUT) ground station located within the field of view of the spacecraft. The UHF SAR distress signal is a digital signal that includes information identifying who the user is. This information may permit a Rescue Coordination Center to dispatch help to the downed aircraft, ship in distress, or individual carrying a PLB directly. If not, an emergency team could be

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alerted while waiting for a LEO SARSAT to fly over the beacon and provide a position based on doppler.

Telemetry, Command, and Ranging

Telemetry, command, and ranging (TC&R) data are downlinked and uplinked between a network of stations, including the Indian Ocean Remote Tracking Station, the NASA Deep Space Network (DSN), and NASA Ground Network (GN) stations for launch and orbit raising, and with the CDA station as the center for the origin of commands and reception of spacecraft telemetry during normal, on-orbit operations (see Section 9).

Subsystem Performance Summary

All services have excess statistical link margin of 1 dB at specification design levels.

Bit error rate limits are as follows:

- Sensor data Imager link 1×10^{-8}
- Sensor data Sounder link 1×10^{-8}
- Processed data relay 1×10^{-6}
- WEFAX/LRIT (coded) 1×10^{-8}
- EMWIN (coded) 1×10^{-8}
- MDL 1×10^{-8}
- Data collection platform Interrogate 1×10^{-5}
- Data collection platform report 1×10^{-6}
- SAR 1×10^{-5}

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Center Frequency Assignments

The GOES satellite center frequency assignments are given in Table 8-1.

Table 8-1. Center Frequency Assignments

| Downlink CF | MHz | Uplink CF | MHz |
|--|------------|--|------------|
| UHF | | UHF | |
| Data collection platform interrogation | | Data collection platform report | |
| Frequency 1 - Spare | 468.8125 | Frequency band 1 - Domestic | 401.900 |
| Frequency 2 - East | 468.8250 | Frequency band 2 - International | 402.200 |
| Frequency 3 - West | 468.8375 | | |
| L/S-band | | SAR | |
| SAR | 1544.500 | Wideband mode | 406.050 |
| WEFAX/LRIT | 1691.000 | Narrowband mode | 406.025 |
| EMWIN | 1692.700 | | |
| DCP report | | S-band | |
| Frequency band 1 | 1694.500 | WEFAX/LRIT | 2033.000 |
| Frequency band 2 | 1694.800 | EMWIN | 2034.700 |
| Telemetry | | DCP interrogation | |
| CDA station | 1694.000 | Frequency 1 - Spare | 2034.8875 |
| DSN | 2209.086 | Frequency 2 - East | 2034.9000 |
| DSN ranging | 2209.086 | Frequency 3 - West | 2034.9125 |
| SD - Raw Imager and Sounder data | 1676.000 | DSN ranging | 2034.200 |
| Processed data relay | 1685.700 | CDA station and DSN spacecraft command frequency | 2034.200 |
| MDL - Multiuse data | 1681.4780 | Processed data relay | 2027.700 |

Sensor Data and Multiuse Data Link Modulators/Transmitters

The SD modulator and the MDL modulator (with its SSPA) share a common housing. The SD modulator accepts the two asynchronous baseband data streams from the Imager and the Sounder. The signals are simultaneously modulated onto the downlink carrier. The Imager data rate is 2.62 Mbps and the Sounder data rate is 40 kbps. The MDL modulator receives the data from the MDL data multiplexer. The data is modulated onto the downlink carrier at a data rate of 400 kbps. Redundancy S-switches for each service select the active string. Both signals are then routed to the output filters, multiplexers, and antennas for transmission.

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Processed Data Relay, Weather Facsimile/LRIT, and EMWIN Transponders

The PDR, WEFAX/LRIT, and EMWIN signals are received by the S-band receive antenna and demultiplexed by the S-band quadruplexer. The active receiver is selected by the S-switch. The active receiver amplifies the uplink band (using low-noise amplifiers) and downconverts it in frequency to an intermediate frequency for filtering. Each signal is individually filtered and then upconverted in frequency. The PDR receiver output is routed to the 2-for-1 redundant PDR SSPA. The WEFAX/LRIT receiver output is routed to the 3-for-2 redundant SSPAs that amplify the WEFAX/LRIT and DCPR signals individually in separate SSPAs (i.e. there is one redundant SSPA that can back up either the DCPR or the WEFAX/LRIT channel). The EMWIN receiver output is already amplified by an SSPA internal to the receiver. Each signal is individually filtered in its assigned output multiplexer and routed to an antenna for transmission. The PDR signal is 2.11 Mbps (2.374 advanced rate) and is band limited by the PDR filter, which has a bandwidth of about 5 MHz. The WEFAX/LRIT signal has an approximately 600 kHz bandwidth. The EMWIN signal has approximately 50 kHz bandwidth.

Data Collection Platform Interrogate Transponder

One of the DCPI uplink carriers is modulated at 100 bps at a center frequency of either 2034.8875, 2034.900, or 2034.9125 MHz. The signal shares the receive antenna and a low noise amplifier with the PDR, WEFAX/LRIT, and EMWIN signals. The receiver includes a channel filter that separates out the DCPI signal and routes it to an internal SSPA for power amplification to transmit power level. An output S-switch selects the active string and routes the signal to the UHF diplexer and antenna for transmission.

Data Collection Platform Report Transponder

Up to 233 DCPR signals may be accommodated in one of the two frequency bands (although 266 channels can be fitted in the allocated bandwidth, international agreements restrict usage to only 233 channels maximum) centered at either 401.900 or 402.200 MHz. These signals — at either 100 bps, 300 bps or 1.2 kbps — are received by the UHF antenna and routed via the diplexer to the SAR/DCPR processor. An input S-switch routes the signals to the active unit, where they are amplified (using low-noise amplifiers) and provided greater than 400 kHz, 3 dB bandwidth filtering in one of two selectable bands. The signals are then upconverted in frequency and amplified with automatic gain control. The output of the selected transponder is filtered and combined with the other S-band downlink signals by the output multiplexer, then transmitted to the ground via the S-band transmit antenna.

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Search and Rescue Transponder

The UHF antenna receives the uplink SAR signals. The uplink band is filtered by the UHF diplexer and routed to the active SAR/DCPR processor via the redundancy S-switch. The processor receives an uplink centered at one of two commandable center frequencies, 406.025 or 406.050 MHz, for narrowband and wideband modes, respectively. The uplink is filtered and downconverted by 406 MHz. These near-baseband signals are amplitude limited and then modulated onto a 1554.500 MHz carrier that is used as the SAR downlink. The SAR/DCPR processor uses an internal SSPA to raise the SAR downlink power for transmission. The output of the selected SAR/DCPR processor is passed through an output filter and finally transmitted via the dedicated SAR transmit antenna.

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