2. GOES Spacecraft Configuration

The GOES-NOP spacecraft is a three-axis, body-stabilized design based on the successful Boeing 601 product line. It features instrument accommodation and design margins for low risk and growth. This permits the Imager and Sounder to continuously observe the earth and thus monitor, track, and acquire extensive data on dynamic weather events. The spacecraft and associated instrument subsystems summarized here are described in more detail in the respective sections of this data book.

On-Orbit Configuration

Figure 2-1 shows the spacecraft in a fully deployed, on-orbit configuration. The Imager and Sounder instruments are colocated with the stellar inertial attitude sensors on a common baseplate supported by structural flexures and attached to the (+Z) nadir panel. The Imager and Sounder electronics, antennas, and multiplexers also reside on the nadir panel. The Imager and Sounder power supplies are mounted on the aft surface (-Z) of the nadir panel along with bus electronics. See Figure 2-3 for a spacecraft expanded overview.

Reaction wheels are mounted to the aft corners of the spacecraft main body. The single panel solar array provides a clear Field of View (FOV) for the Imager and Sounder coolers, maximizing their radiometric performance. The solar array, populated with efficient dual-junction gallium arsenide solar cells, has been optimized to provide ample power while stowed for the spinning transfer orbit and when deployed in the on-orbit configuration. Dual junction cells minimize array size to support substantial Attitude Control System (ACS) momentum storage margins.

Clear FOVs are provided for all instrument apertures and thermal radiators. The Imager and Sounder radiant coolers have a near hemispherical FOV with only minor thermal backloading coming from the deployed magnetometer boom. Elimination of the solar sail used on GOES I-M removes the major contributor to thermal backloading and results in a measurable increase in radiometric performance.

The Solar X-Ray Imager (SXI), X-Ray Sensor (XRS), and Extreme Ultraviolet (EUV) sensor are mounted on an N-S gimbaled platform attached to the solar array yoke. The Space Environment Monitor (SEM) instruments are located on the zenith/aft (-Z) side of the spacecraft except for the energetic proton, electron, and alpha detectors, which are located on the exterior face of the south facing (–Y) bus radiator panel.

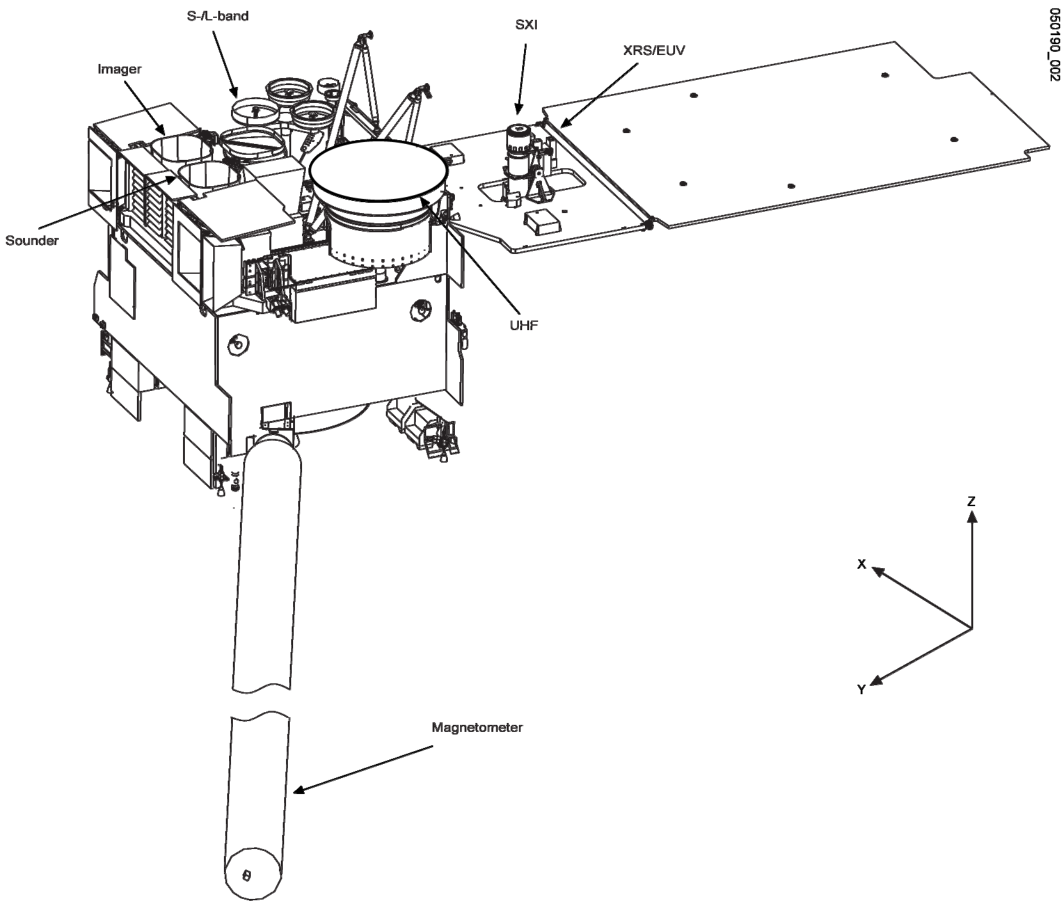

Figure 2-1. Spacecraft On-orbit Configuration

An uncontaminated magnetic field at the magnetometer is ensured by the use of an 8.5 meter boom. Detailed analysis has shown the boom to be fully compatible with the spacecraft control system with no impact on INR performance. The deployed boom is encapsulated by a "thermal sock" that averts distortion caused by differential shading and protects against thermal snap.

The basic spacecraft bus provides most of the essential features required to satisfy GOES stringent electromagnetic compatibility requirements. Bus electronics and the major propulsion components are located inside the bus cavity, which is enclosed by an all aluminum exterior that functions as an EMI-tight Faraday cage.

Launch Configuration

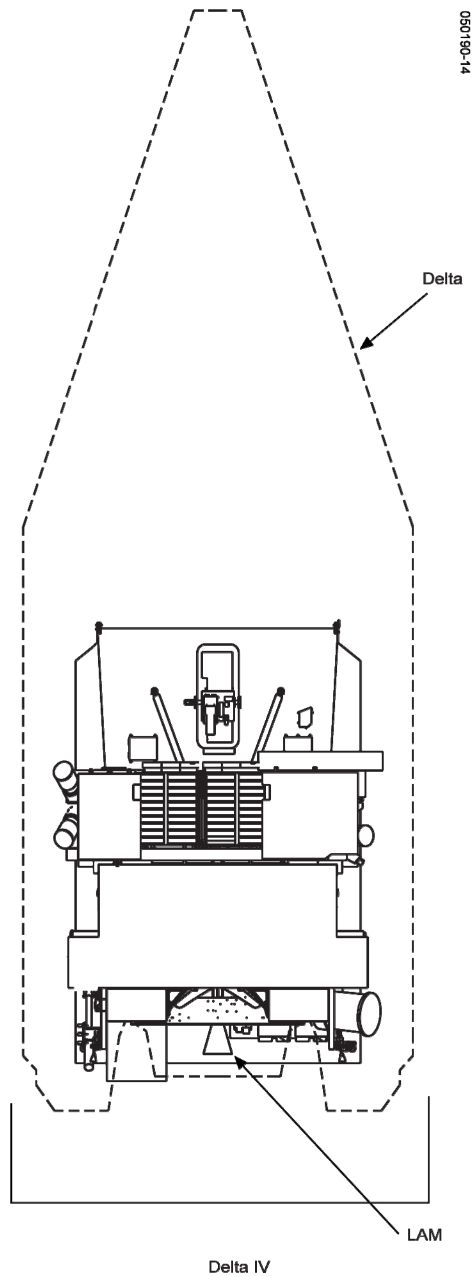

Figure 2-2. Launch Configuration

The compact stowed configuration is fully compatible with the Delta IV (Figure 2-2) launch vehicle. Coupled loads analysis confirms adequate design margins for critical instrument launch loads and shows robust margins on the bus, which has been qualified for payloads much larger than GOES-NOP. For contamination protection, the Imager and Sounder apertures are covered during launch and ascent. Stowed mass properties support a benign separation and an operationally simple, passively stable spinning transfer orbit mode, which is standard for all Boeing 601 spacecraft. Transfer orbit power is supplied by the stowed solar array. No time-critical deployments are associated with transfer orbit operations.

Boeing 601 Heritage

Spacecraft subsystems for GOES-NOP retain extensive heritage from the Boeing 601 product line. Primary structural modifications consist of adding the Imager/Sounder baseplate and magnetometer boom, resizing the solar array, redesigning the yoke, and adding Faraday enclosures for nadir mounted electronics. The communication subsystem consists of existing design components tailored for GOES requirements. The power electronics have been modified to include a 42 volt instrument bus, a single point ground, and low magnetics. Both controls and T&C electronics have been modified to accommodate instrument interfaces. Slip rings have been added to the Solar Array Drive (SAD)/Electrical Contact Ring Assembly (ECRA) to accommodate signals from the yoke-mounted instruments.

Subsystem Design and Margins Summary

The overall subsystem hardware architecture, along with component redundancy and key functional relationships, are shown in Figure 2-3. All subsystems have been designed to accommodate growth specified for the Government furnished equipment (GFE) instruments and show margin above this growth configuration. The following paragraphs briefly describe each subsystem.

Structure and Mechanisms

The major components of the structure subsystem are the cruciform assembly with propulsion supports, the north-south radiators, east-west closeout panels, a thrust tube, and the launch vehicle adapter interface. The propulsion tanks are mounted inside the bus cavity, which serves as the structural support and Faraday cage enclosure. The SAD, with its integral ECRA, provides the mechanical and electrical interface between the solar array and yoke-mounted sensors and the spacecraft bus. The Solar Array Actuator (SAA), which deploys the solar array, is the viscously damped spring-driven actuator used on the Boeing 601. The X-Ray Positioner (XRP) is a combination of the standard Boeing 601 motor, existing gearhead, and an existing Alternate Bearing Support (ABS).

Thermal

Thermal regulation of the spacecraft is accomplished through a combination of multi-layer insulation, radiators, and automatic heater control. The primary spacecraft radiator is located on the south side (-Y, solar panel facing). For high thermal dissipaters, flight-proven Boeing 601 heat pipes are used to channel thermal energy to the radiators.

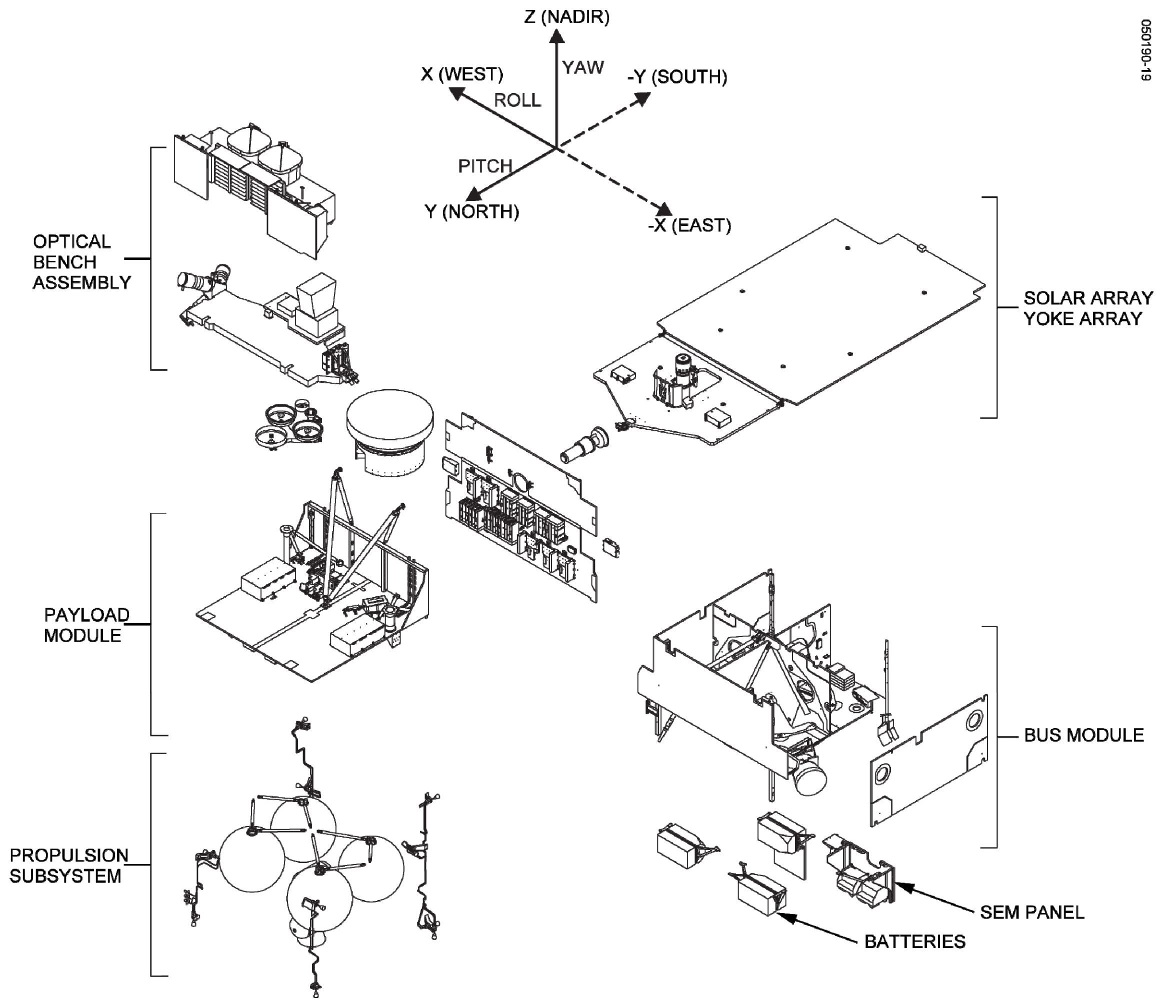

Figure 2-3. GOES-NOP Spacecraft Expanded Overview

Electrical Power Subsystem

The integrated power controller (IPC) coordinates the storage, regulation, and dissipation of the generated power. On-orbit solar array power is provided by a deployable solar array populated with high-efficiency dual-junction gallium arsenide solar cell circuits. A 24-cell nickel-hydrogen 123 A-hour battery, configured as three 8-packs, stores electrical energy. The power distribution units (PDUs) distribute fused load power via three closely regulated power buses at 53, 42, and 30 volts. Heater control relays are incorporated into each PDU to provide switching for heater loads.

Imager and Sounder

The Imager and Sounder are the two primary GOES instruments. The Imager is used to sense five channels of visible and infrared radiant and solar reflected energy from sampled areas of the earth. The Sounder is a 19 channel visible and infrared discrete filter radiometer that senses specific data parameters for atmospheric vertical temperature and moisture profiles, surface and cloud top temperature and ozone distribution. Both instruments are capable of providing full earth and sector imagery as well as scans of local regions. The Imager and Sounder are independent instruments that can be operated simultaneously. Both are GFE built by ITT.

Space Environment Monitor

The SEM subsystem is used to monitor the conditions of the space environment and to determine when to issue forecasts, alerts, and warnings. It provides alerts of space weather conditions that may interfere with ground and space systems. The subsystems consist of the XRS, the EUV sensor, EPS (consisting of the Magnetospheric Proton Detector [MAGPD], Magnetospheric Electron Detector [MAGED], Energetic Proton Electron Alpha Particle Detector [EPEAD]), HEPAD, and dual magnetometers. The magnetometers are mounted near the end of the 8.5 m boom and measure Earth's varying magnetic field in the vicinity of the spacecraft. The XRS and EUV detect solar x-ray and extreme ultraviolet (EUV) solar radiation. They are colocated with the SXI on the solar array yoke. Two EPEADs facing east and west are used to meet the coverage requirements for solar energetic protons, electrons, alpha particles and radiation belt electrons. The magnetospheric particle detectors consisting of the MAGED for electrons, and the MAGPD for protons cover the zenith hemisphere and are based on the detectors used in the POES/NOAA SEM suite. The HEPAD is the same unit flown on GOES I-M, oriented to look toward zenith in order to meet the coverage requirements for high-energy solar protons and galactic cosmic rays.

Solar X-ray Imager (SXI)

The SXI is a GFE instrument built by Lockheed Martin and used to determine when to issue forecasts and alerts of space weather conditions that may interfere with ground and space systems. It consists of a telescope imaging the solar corona in the soft x-ray to XUV region of the electromagnetic spectrum. The SXI telescope is mounted on the x-ray positioner (XRP) and its three electronics boxes are mounted on the solar array yoke of the GOES spacecraft.

Telemetry and Command

The T&C subsystem is partitioned into an RF group and a digital electronics group. The RF group consists of an aft (-Z) omni antenna and forward (+Z) S-band and L-band horn antennas and transponders. The uplink command is received by both the forward S-band and aft omni antenna. CDA telemetry is transmitted via the aft omni and forward L-band antenna. DSN telemetry is transmitted via the aft omni and forward S-band antenna during transfer orbit operations.

The digital group consists of the central telemetry and command units (CTCUs), remote telemetry and command units (RTCUs), and squib driver unit (SDU), all having Boeing

601 heritage. The CTCU decrypts and decodes the uplinked ground commands and multiplexes and formats the downlink telemetry into two simultaneous downlink data streams: one for the DSN link and one for the CDA link. The multi-use data link (MDL) analog data multiplexer within the instrument RTCU (IRTCU) multiplexes and formats the dynamics (e.g., instrument servo error) data, SXI image and housekeeping data and duplicates of the two spacecraft normal telemetry streams for transmission to the ground. The CTCU distributes spacecraft commands and gathers telemetry from the RTCUs via the bi-directional, redundant 1553 T&C databus. The squib driver unit (SDU) provides electrical power for pyrotechnic release devices.

Communications

The communications subsystem provides the antennas and transponders for the data repeater services, which include the PDR, SAR, WEFAX/LRIT, DCPI/DCPR, and EMWIN, and the on-board data transmit services, which include the SD and MDL. The communication antennas consist of two L-band and one S/L-band antennas on a common structure and a UHF cup dipole antenna. One of the L-band antennas is used for the SAR downlink. The UHF antenna receives both the SAR and DCPR uplink. The S/L-band antenna receives the S-band uplink as well as transmits the MDL and DCPR and WEFAX/LRIT downlink signals, and the other downlink L-band antenna is used for downlink of the SD, PDR, and EMWIN downlink services. Multiplexers are used in conjunction with the UHF, S/L-band, and L-band antennas, which handle multiple services. An S-band receiver amplifies and frequency translates uplink S-band signals for PDR, WEFAX/LRIT, EMWIN, and DCPI. A SAR/DCPR processor is used to receive the UHF uplink signal, amplify, frequency translate, and process the UHF SAR and DCPR signals. A common modulator unit is used for the SD and MDL digital data that is passed from the Imager/Sounder instrument and IRTCU, respectively. The SAR/DCPR processor, S-band receiver, and MDL/SD modulator employ solid-state power amplifiers (SSPAs) to amplify the downlinks to the proper transmit level. All active hardware in the subsystem is fully redundant and cross-strapped by both passive power splitter/combiners and coaxial switches.

Propulsion

The bipropellant propulsion subsystem uses the hypergolic combination of monomethylhydrazine (MMH) fuel and nitrogen tetroxide (NTO) oxidizer for efficient thrust. Regulated helium pressurant is supplied to four spherical propellant tanks. Each tank incorporates a gallery type propellant management device (PMD) that delivers gas-free propellant to the thrusters. Independent latch valves (LV) allow selective propellant withdrawal for distribution control. A 490 N LAM is used for ascent maneuvers, while a suite of twelve 9.25 N thrusters provide attitude and spin speed control.

Attitude Control Subsystem

The ACS architecture consists of both transfer orbit and on-orbit attitude sensors and actuators, which are centrally coordinated by the attitude control electronics (ACE). The ACE contains the dedicated on-board processor. Primary software functions include attitude control, thruster operation, and solar array stepping. Additionally, the ACE autonomously handles routine spacecraft maintenance such as battery charge management, heater control, momentum management, and fault detection and correction. On-orbit attitude control is achieved by operating four high-capacity reaction wheels in a zero-momentum configuration, 3-for-2 redundant star trackers, and a hemispherical inertial reference unit (HIRU) for attitude determination. Slit-type sun sensors and earth sensors provide attitude references during spinning transfer orbit operations. The ACE supports an analog and digital interface to the Imager and Sounder, which supplies mirror steering via image motion compensation (IMC) and dynamic motion compensation (DMC) signals. Thrusters and tank latch valves are operated directly by the ACE in support of maneuvers and momentum management.