16. Spacecraft Mission Profile

To reach the required on-station location in geostationary orbit (station acquisition), the GOES spacecraft undergoes four distinct mission phases:

- ***Launch phase***—From Delta IV liftoff to spacecraft separation
- ***Transfer orbit phase***—Spacecraft separation to the last perigee motor firing (PMF)
- ***Deployments, acquisition, and bus in-orbit test phase***—From the last PMF to Spacecraft in Normal Mode to engineering handover (from Boeing to NASA operators).
- ***Post Launch Test and On Station*** Performance testing of the payloads to initial operations

The nominal chronological sequence of orbit raising for a nominal transfer orbit consists of reorientation to apogee firing attitude, apogee motor firing (AMF) 1, AMF 2, AMF 3, AMF 4, and AMF 5. The spacecraft is passively spin stabilized around the +Z axis. After the last AMF, the solar array is deployed, and the spacecraft transitions to three-axis stabilization mode.

Ground Stations

Various ground centers and tracking stations are involved throughout the mission phases:

- Deep Space Network (DSN) stations at Canberra, Australia; Madrid, Spain; and Goldstone, CA, support orbit raising maneuvers with Goldstone acting as backup to the command and data acquisition (CDA) station when the spacecraft achieves synchronous orbit.
- Diego Garcia Station (DGS), an Air Force remote tracking station, is used for initial spacecraft separation telemetry and command (T&C) functions and to support the transfer orbit during the first 3 days.
- CDA station located at Wallops, VA, houses the T&C transmission system (NTACTS), portions of the spacecraft support ground system (SSGS), and GOES telemetry and command system (GTACS). The CDA performs spacecraft telemetry acquisition, formatting, command transmission, and ranging.

- Satellite Operations Control Center (SOCC) houses the orbit and attitude tracking system (OATS), part of the SSGS, and GTACS. The SOCC is the prime control center during all mission phases. This station is also capable of receiving processed instrument data in GOES variable (GVAR) data format and multiuse data link (MDL) diagnostic data.

Launch and Injection

The GOES N-Q spacecraft are launched from Cape Canaveral Air Force Station Launch Complex 37B by a Boeing Delta IV rocket. Major flight events and times for the Delta IV mission are shown in Table 16-1. Spacecraft telemetry is provided through the launch vehicle telemetry until separation. The launch vehicle trajectory includes a third burn of the second stage at the transfer orbit apogee. This involves a long coast period (4 hrs) with the launch vehicle performing a slow roll maneuver to provide good thermal and power conditions for both the spacecraft and launch vehicle. The GOES spacecraft is separated from the upper stage of the Delta IV with a spin about its +Z axis at the time of ground station acquisition of signal. The +Z axis of the spacecraft is pointed to provide both good sun and communications, providing an effective T&C signal for first acquisition of signal and maintaining good power on the solar arrays. The Delta IV injects the spacecraft into a geosynchronous transfer orbit with the following orbital parameters: 41555 km apogee radius, 13000 km perigee, 12° inclination to begin the transfer orbit phase. The time from liftoff to separation is about 4.5 hours.

Table 16-1. Delta IV Major Mission Events

Event	Time Lapse from Ignition, sec
Ignition	0
Maximum dynamic pressure	61
Jettison ground lit solid motors	100
Main engine cutoff (MECO)	267
Second stage ignition	287
Jettison fairing	297
Second stage cutoff 1 (SECO-1)	757
Second stage restart	1385
Second stage cutoff 2 (SECO-2)	1628
Begin Coast Phase Roll	1620
End of Coast phase Roll	14400
Second Stage Restart	15001
Secon Stage cutoff 3 (SECO-3)	15057
Spacecraft separation	15687

Transfer Orbits

The spacecraft attitude at injection is oriented so as to maximize continuous T&C coverage by Canberra ground station and maximize sun angle on the solar array. The T&C omni antenna is initially in a stowed position for launch, but after initial station acquisition, it is deployed. The effective spacecraft T&C antenna pattern once deployed is a cardioid with a maximum ±110° look angle from the -Z axis. T&C visibility from the ground is obtained when the spacecraft's elevation angle with respect to the ground station local horizon is greater than 5°, and the ground station is within the spacecraft T&C antenna pattern. During transfer orbits, redundant and near-continuous coverage is provided by the three T&C stations (Goldstone, Madrid, and Canberra).

After acquisition of signal by Canberra is established and a command link verified, the omni antenna is fully deployed. The spacecraft is then configured for transfer orbit operations. This consists of pressurization of the propellant system and checkout of the thrusters and attitude control electronics (ACE).

The 490 N liquid apogee motor (LAM) is used to target the spacecraft into the proper geostationary orbit, that is, correct apogee radius, inclination, and ascending node. Propellant consumption and burn duration are minimized by using the LAM, which has higher specific impulse and higher thrust compared to the 9.25 N stationkeeping thrusters.

The launch and orbit raising mission phases are shown in Figure 16-2. Nominal transfer orbit parameters are given in Table 16-2. Optimum targeting also involves splitting the apogee maneuvers into several burns. Orbit and attitude determinations are performed throughout this period to assess maneuver performance, and the mission plan is adjusted to account for the actual performance of the system.

Table 16-2. Nominal Transfer Orbit Parameters

	Post Separation	Post AMF1	Post AMF2	Post AMF3	Post AMF4	Post AMF5
Perigee radius, km	13000	19532	35256	40488	41482	42155
Apogee radius, km	41555	41546	41525	41537	42168	42175
Inclination, deg	12.0	6.6	1.3	.48	0.42	.5
Period, hr	12.5	14.8	20.8	23.0	23.6	24.0

The size of the maneuvers and phasing are set up to target the initial longitude. These maneuvers will attain the geostationary orbit. Table 16-2 provides a nominal set orbit parameters for the transfer orbit sequence. The spacecraft arrives on station about 12 days after launch vehicle separation. During the post launch test period, which follows, the 9.25 N stationkeeping thrusters will be used to adjust the orbit and initialize the orbit for the operational stationkeeping cycle.

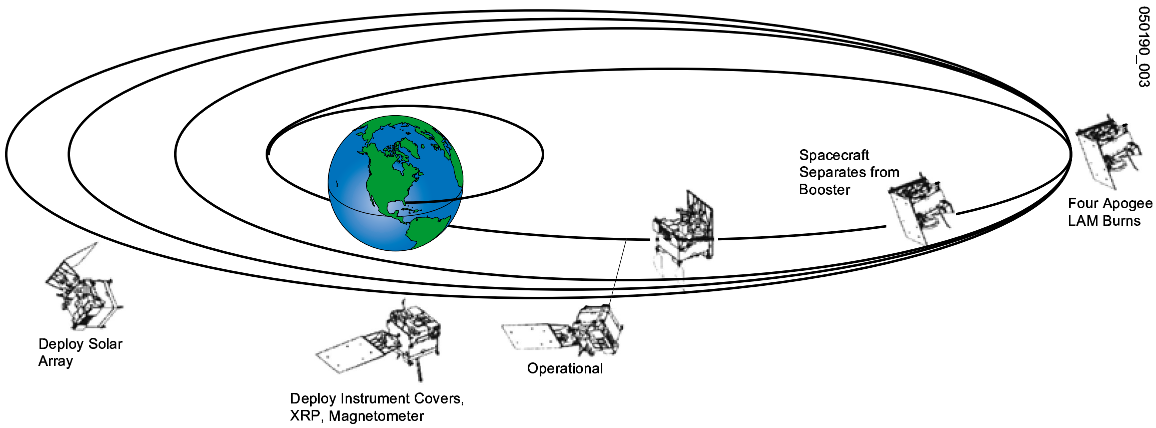

Figure 16-2. Launch and Orbit Raising Mission Phases

A set of mission plans detailing the maneuvers and showing ground station visibilities are provided as part of the Mission Operations Plan.

Deployments, Acquisitions, and Bus In-Orbit Test

After the last LAM burn is complete and the spacecraft is at the initial test longitude, a period of approximately 6 days passes until the spacecraft is configured for three-axis stabilization mode and tested in preparation for the extended post launch test phase. The first day is used to deploy the solar array. This begins with a spin down, a reorientation to the proper attitude, and the release of the array. Once the solar array is deployed, the spacecraft uses thrusters to acquire the sun. The spacecraft uses reaction wheels to maintain itself in a sun hold configuration. After this, the instrument mounting platform (IMP) is deployed, and the precision sun sensor (PSS) and XRS/EUV are initially checked out. The star trackers are then tested, and the stellar inertial attitude system is initialized. When this is complete, the spacecraft is placed in normal mode and slews to an earth-pointing orientation. The spacecraft is now operating as a three-axis stabilized spacecraft. The next few days are then devoted to configuring the battery and heaters, checking out communications payloads, deploying the magnetometer, turning on space environment monitor (SEM) instruments and testing those spacecraft subsystems that are going to be needed for post launch test. The last deployments prior to engineering handover are the deployment of the Imager and Sounder Optical Port Covers. At this point, the spacecraft is ready for engineering handover from Boeing operators to NASA operators.

Post Launch Test Phase and On-Station Orbit

After the engineering handover is complete, post launch test begins, and the spacecraft is checked for proper performance before entering service at either of two assigned locations. At the 90 W checkout station, the orbit apogee and perigee radii will respectively be 156 km above and below the geosynchronous radius of 42,164 km. By international agreement for the GOES system, two spacecraft orbital positions have been assigned: 75° and 135° West longitudes. From these two vantage points, roughly over Ecuador and the Marquesas Islands, respectively, the GOES Imager and Sounder instruments cover both the Atlantic and Pacific oceans. The major operations performed upon station acquisition are:

- Outgas Imager and Sounder contaminants
- Activate and checkout Communications payload data services
- Deploy Imager and Sounder cooler covers
- Activate space environment monitor equipment
- Characterize and optimize Imager and Sounder radiometric performance
- Activate and evaluate Image Navigation and Registration
- Enter storage mode or begin on-station operations

Normal on-orbit operations entail periodic stationkeeping maneuvers that keep the spacecraft within a 0.5° inclination about the equator and within ±0.5° of the on-station longitude. These maneuvers are needed because of several forces that produce small changes over a short period of time: interactive effects of the sun's and moon's gravity, solar radiation pressure, and the earth's gravitational field. Stationkeeping is performed by a pair of east or west thrusters to maintain station longitude and a pair of north thrusters to maintain orbital inclination.

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