



Deployment Mechanisms and Structures

Several spacecraft appendages are stowed during launch and later deployed at various mission phases, starting soon after separation of the spacecraft from the launch vehicle. The deployable appendages are:

- Solar array
- Magnetometer boom
- Solar sail and boom
- Imager and Sounder radiant cooler covers

These deployments are initiated by ground commands and occur at three different time periods:

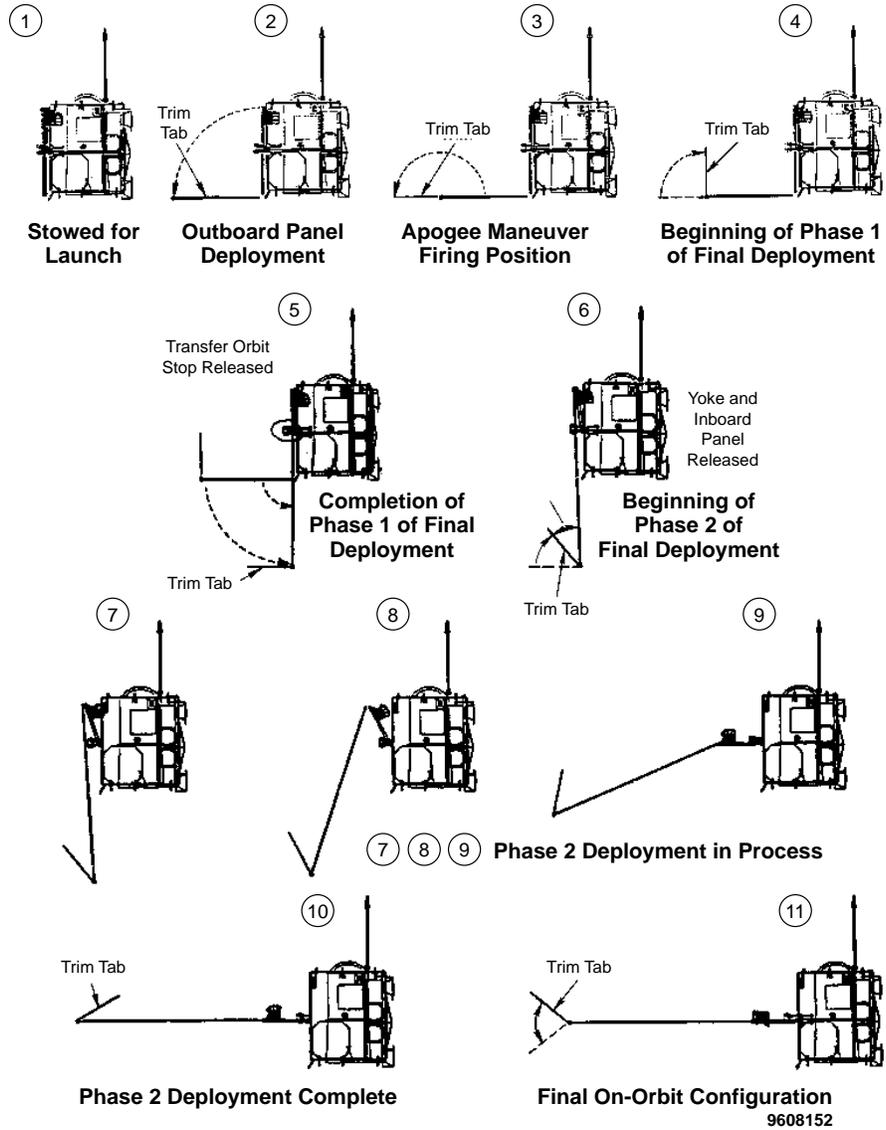
- First, early in the transfer orbit, about 90 minutes after launch, the outer solar panel is partially deployed to about 90° from its launch position, exposing its solar cells to the sun and providing power for the spacecraft during the transfer-orbit phase.
- Later, shortly after completion of all apogee maneuvers required for orbit raising and early in the near-geosynchronous drift orbit:
 - The magnetometer boom is deployed.
 - The final phases of solar array deployment are completed.
 - After the spacecraft is in wheel control mode, the solar sail and boom are extended.
- Finally, after 14 to 21 days of outgassing in space, the Imager and Sounder radiant cooler covers are deployed.

All of the deployable appendages are released by pyrotechnically driven cutters (electroexplosive devices, EEDs) that cut a tensioned cable or rod holding the appendage in its stowed, launch position. The cutters are fired by ground command. All cutters are fully redundant with independent knives, firing circuits and commands. If the first cutter does not release the appendage, the redundant cutter may be used later.

Solar Array

The solar array consists of two panels covered with solar cells on one side and a yoke that holds the panels away from the spacecraft to avoid shadows on the cells. The yoke is mounted to the shaft of the solar array drive assembly (SADA) on the body of the spacecraft. When fully deployed, the solar array extends from the south side of the spacecraft where the SADA continuously rotates to keep the solar cells oriented towards the sun. The panels and yoke are hinged together so they can be folded against the south side of the spacecraft during launch; they are held in place by latches with tensioned cables.

Solar Array Deployment Sequence





Upon ground command, the panels are released by cutting the cables with an EED. The panels are deployed to their operational positions in three discrete steps: transfer orbit, phase 1 of synchronous orbit, and phase 2 of synchronous orbit. Deployment is driven by the unwinding of redundant prewound torsion springs at each hinge. Switches on each hinge line indicate, by telemetry, when the panels are near their deployed position.

Transfer Orbit

The initial, transfer-orbit deployment occurs soon after launch with the spacecraft in the off-axis, sun acquisition control mode. In this mode, the sun warms the hinges prior to deployment. The outer panel is released by firing a cutter that severs the primary holddown cable. With the cable slack, six spring-driven latches rotate clear of holddown rods freeing the outer panel to deploy. The inner panel and yoke are retained in their stowed position by a secondary holddown system which is similar to the primary system. After rotating about 90°, the outer panel is stopped at its transfer-orbit position by removable mechanical stops that engage the hinges. In this position the cell side of the outer panel is exposed to the sun, thus generating power to support the spacecraft electrical load. The trim tab, which is stowed behind the outer panel, is slewed 180° so that it is inplane with the deployed, outer panel.

Phase 1 Synchronous Orbit

After orbit raising with the spacecraft near its geosynchronous orbit position, solar array deployment is completed. The spacecraft is in the pitch earth acquisition control mode with the sun warming the outer panel and hinges. The cable retaining the transfer-orbit stops is cut. This allows the stops to move out of the way thus freeing the outer panel to complete its 180° deployment and to latch. The trim tab must be slewed to its 90° position at the start of this phase to reduce moment loads on the trim tab motor at latch-up.

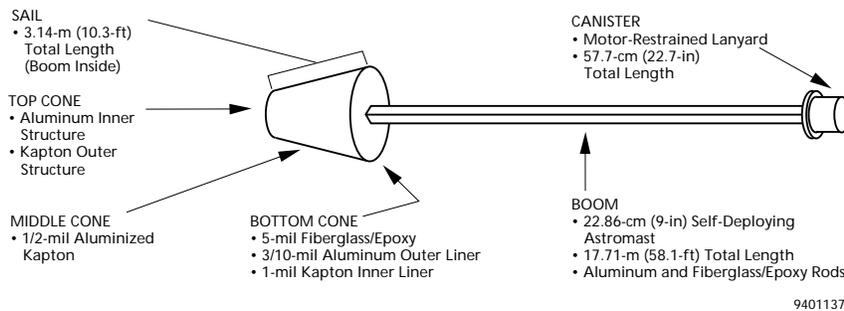
Phase 2 Synchronous Orbit

In DIRA attitude reference control mode, the spacecraft is rotated about the yaw axis to allow the sun to warm the inner panel and the yoke-to-inner-panel hinges. After warming for about 40 minutes, the secondary holddown/release retaining the yoke and inner panel is fired, cutting a cable and freeing the entire wing to deploy. The yoke rotates 90°, while the inner and outer panels rotate together 180° (with respect to the yoke). The SADA-to-yoke and yoke-to-inner panel hinges latch, completing the solar array deployment.



Solar Sail and Boom

Design Description, Solar Sail and Boom

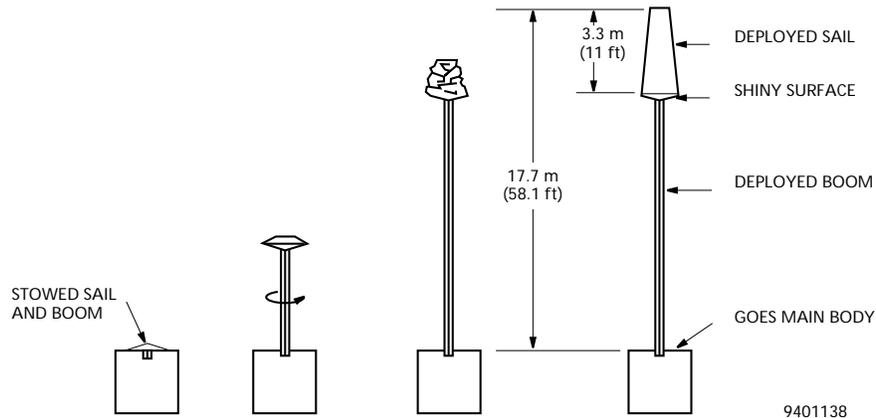


To balance the torque caused by solar pressure on the solar array, a solar sail is deployed from the north side of the spacecraft, opposite the solar array. The sail is mounted on an extendable boom (Astromast). The sail and boom are lightweight collapsible structures, mounted on the north face of the spacecraft. During launch, the boom is stowed in a canister and the sail is folded against the north face. The sail and boom are held in their stowed positions by a metal tie rod that extends through the stowed boom assembly and into a redundant pyrotechnic cutter. Severing the rod with the cutter releases the sail to deploy and the boom to extend to a total length of 17.7 meters (58.1 feet).

When released the coiled boom jumps a few centimeters (about 1 inch) from its canister and is restrained by a lanyard fastened to the outer end of the boom. To obtain a slow, safe boom extension, the lanyard is payed out from a reel controlled by a redundant dc motor. At the end of its extension, the boom latches into a stiff configuration and the sail is fully deployed. Deployment switches indicate the initial jump-out and the start of motor-controlled extension. During extension, up until the boom latches into its stiff configuration, the motors may be stopped to halt deployment, though it is not possible to reverse the motors and retract the boom.



Solar Sail and Boom



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Two redundant, miniature, dc-torque motors control the extension rate of the boom. When the boom is completely deployed, a redundant pair of switches on each motor actuate, disconnecting motor power which stops the motors. If any pair of switches fails to operate, the motor continues to run as long as the execute signal is being sent. If this happens, the end of the lanyard will disconnect from its reel to prevent damage.

Magnetometer Boom

The magnetometer boom moves two redundant magnetometers away from the spacecraft main body to reduce interaction with the spacecraft's magnetic field. The boom is a thin-walled graphite tube, 3 meters (9.8 feet) long and 5 centimeters (2 inches) in diameter. One end of the boom is hinged to the northwest corner of the anti-earth panel. The other end of the boom holds the two magnetometers. One magnetometer is 0.3 meter (1 foot) inboard of the other. The boom and the magnetometer support brackets are made of graphite epoxy for low mass and small thermal distortions.

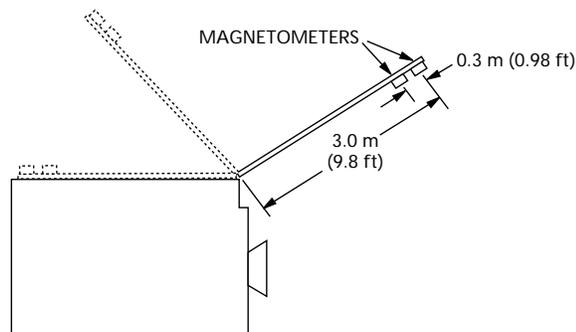
During launch, the magnetometer boom is stowed diagonally across the anti-earth panel. It is held by a single holddown/release device located between the two magnetometers. A tensioned cable preloads the boom against the holddown bracket. Upon ground command, a pyrotechnically actuated cutter severs the cable releasing the boom for deployment. Deployment is driven by two redundant torsion springs located on either side of the hinge. The boom rotates 135° from its stowed to its deployed position. If needed, a redundant cutter is available.

In the deployed position, the boom is locked in position by a roller/latch-arm that follows a cam during deployment and enters a close-tolerance slot at the



deployed position. The roller and latch arm are held against the cam and pushed into the slot by multiple leaf springs. Once so engaged, any further motion or vibrations will not cause the roller to leave the slot. Deployment switches indicate release from the holddown device and latching in the deployed position.

Stowage and Deployment of Magnetometer Boom



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Imager and Sounder Radiant Cooler Covers

The two cooler covers, one each for the Imager and Sounder, serve to:

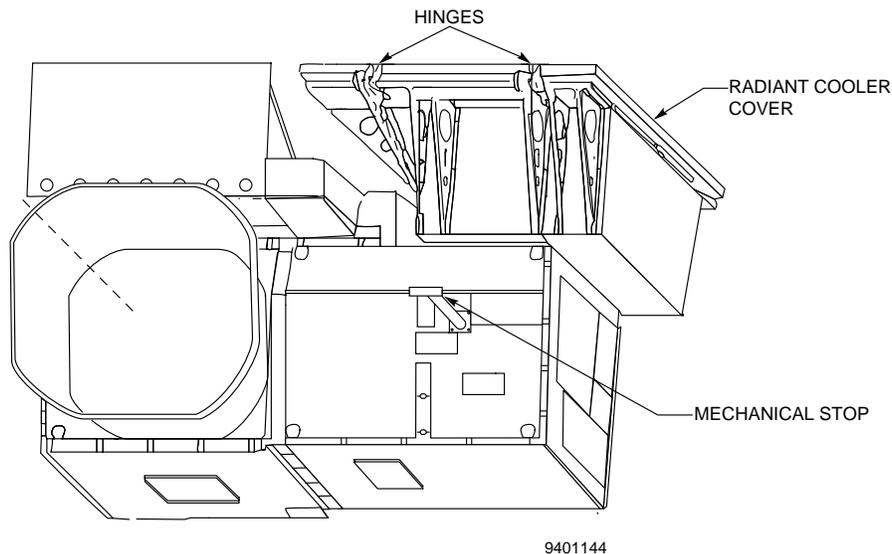
- Protect the infrared detectors from direct sunlight during orbit insertion
- Protect the radiant cooler and emitters from contamination during launch and orbit insertion
- Reduce outgas heater requirements at acquisition of geosynchronous orbit

Each cooler cover consists of an aluminum/honeycomb sandwich panel, two spring-driven deployment hinges, a holddown/release device (pyrotechnically actuated), and thermal blankets on the inside and outside. Each cooler cover attaches to the cooler assembly. The hinges attach to the external shroud and are isolated thermally by fiberglass standoffs. The holddown/release device attaches to the emitter panel. Pretensioning devices for the holddown cable are mounted on the external shroud.

During launch, each cooler cover is held in the stowed position by a cable that preloads the cover to the emitter panel. Upon ground command, pyrotechnically actuated cutters (one at each cooler cover) sever the cables, simultaneously releasing both covers for deployment. Deployment is driven by redundant torsion springs located on the hinges. Each cover rotates 270° from its stowed to its deployed position. At the deployed position, each cover hits a mechanical stop and is held against the stop by the residual deployment spring torque and by a Velcro fastener. If needed, a redundant cutter is available.



Instrument with Cover in the Closed Position



Microswitches on the deployment hinges indicate stowed and fully deployed positions. Deployment is also indicated by changes in temperature of the lower cooler housing, the radiator, and the infrared detector.

Spacecraft Structure

The GOES spacecraft main body consists of a graphite-fiber-reinforced plastic (GFRP) central cylinder that houses the propellant and oxidizer tanks of the propulsion subsystem, a propulsion panel, momentum wheel panels, external panels mounted to longerons, and struts supported by the central cylinder. The panels are of sandwich construction with aluminum honeycomb core and either GFRP or aluminum faceskins. The struts are made of GFRP tubes and the longerons are aluminum.

The solar array structure consists of the yoke, two solar panel substrates, and the trim tab panel. The yoke structure is made of GFRP beams. The solar panel substrates are of sandwich construction with lightweight aluminum honeycomb core and thin GFRP faceskins. A thin Kapton film (3-mil thick) is bonded to the solar cell side of the substrates to electrically insulate the solar cells from the graphite faceskin. The solar cells are bonded to the Kapton film. The trim tab panel is of sandwich construction with a lightweight aluminum honeycomb core and thin GFRP faceskins.