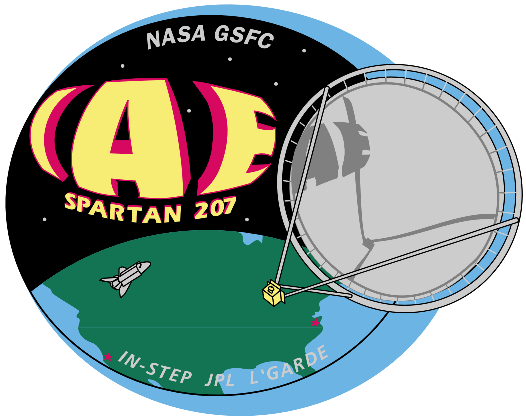
L • GARDE INC. CORPORATE PRESENTATION

Spartan 207/ Inflatable Antenna Experiment Flown on STS-77

Spartan Project
Code 740.1
NASA Goddard Space Flight Center
Greenbelt, MD

February 14, 1997

Preliminary Mission Report



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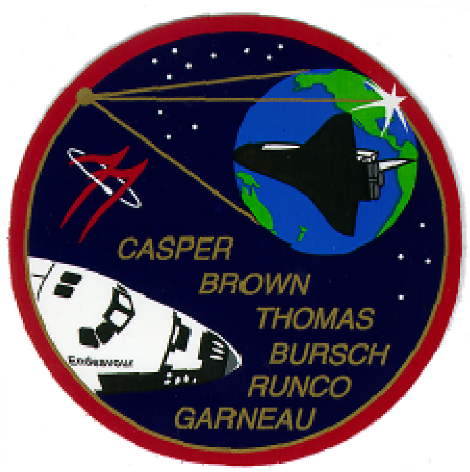

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Overview

STS-77 began on May 19, 1996 with the launch of Space Shuttle *Endeavour*. Onboard was Goddard Space Flight Center's (GSFC) eighth Spartan mission to fly into space, the Spartan 207/ Inflatable Antenna Experiment (Sp207/IAE). The goal of this Spartan mission was to inflate a 14 meter antenna on three 28 meter struts built by L'Garde, Inc. under contract to the Jet Propulsion Laboratory (JPL). This demonstration of new technology was developed under NASA's In-STEP technology development program.

The spacecraft was nominally deployed by the crew using the Remote Manipulator System (or RMS, the robotic arm) on Flight Day 2. With all spacecraft functions operating correctly, the antenna was inflated at the proper time 1 1/2 orbits later, just after orbital sunrise. The IAE experienced unexpected dynamics during the initial ejection and inflation of the inflatable structure, but the correct final shape was attained. After full inflation of the antenna structure, the spacecraft began rotating unexpectedly. During the inflation process and throughout the science orbit, Endeavour's crew took extensive video, photographs, and motion pictures of their activities.

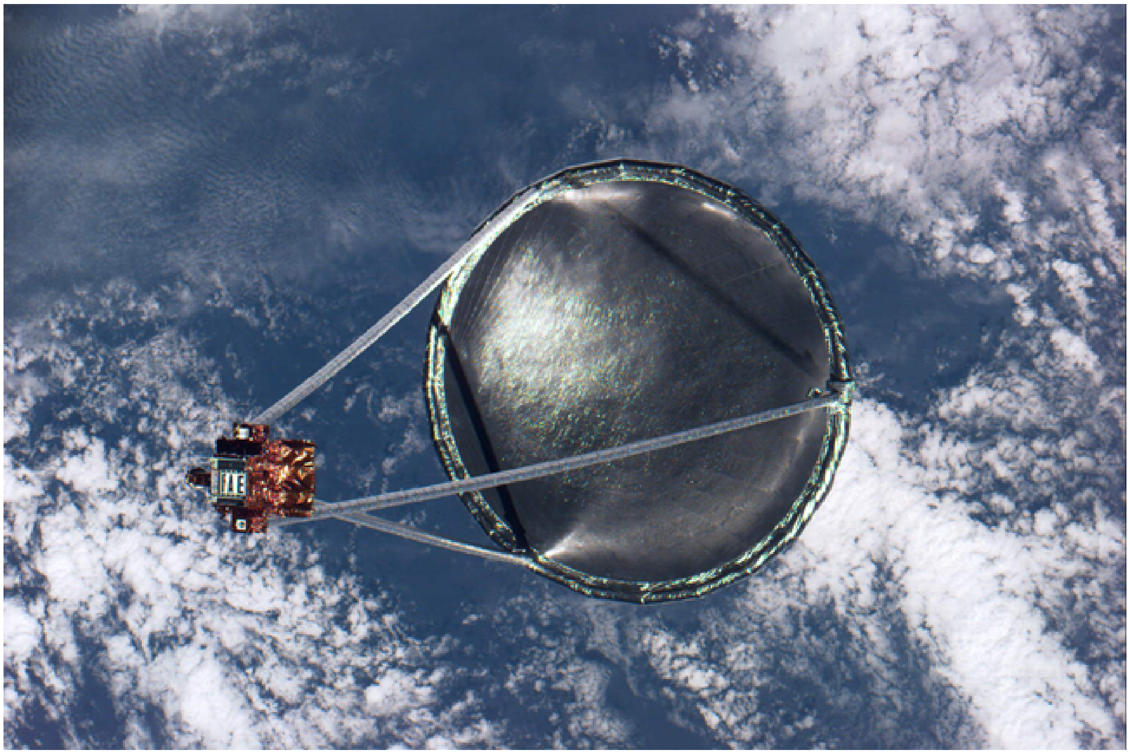
After reaching the desired orbit for science operations, the inflated antenna was jettisoned from the Spartan 207 spacecraft. On the following day, the Spartan 207/IAE was successfully retrieved and stowed for return to Earth.

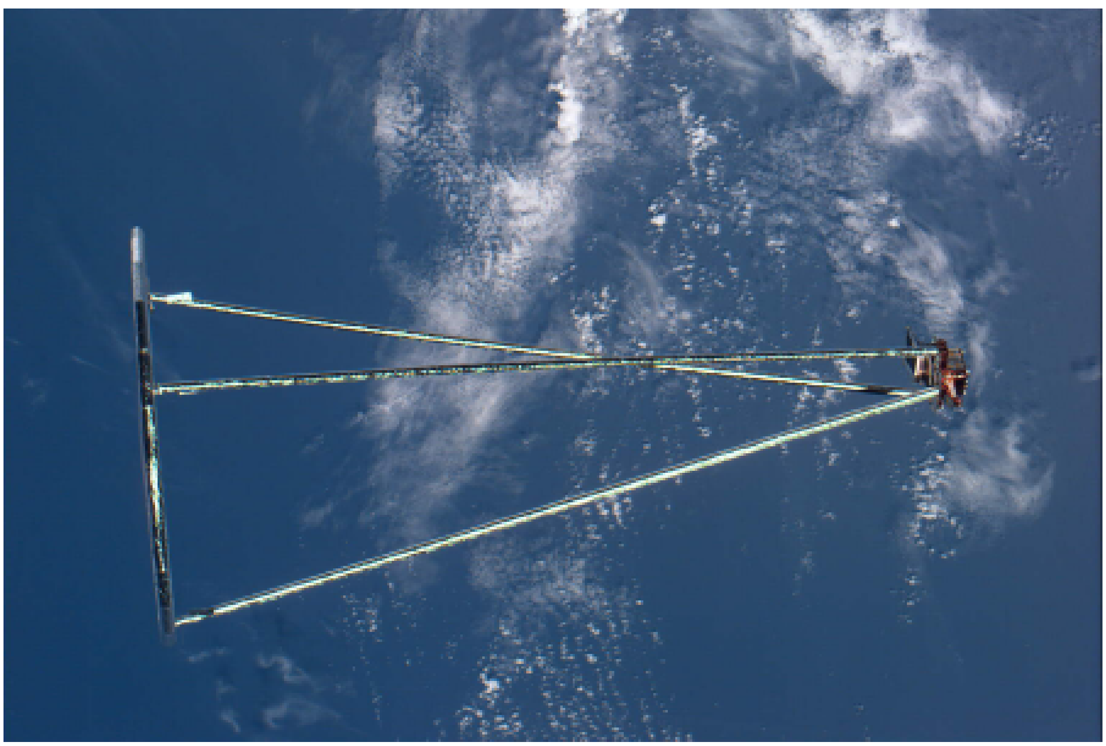
In early June, the payload team gained access to the spacecraft after it was removed from the Orbiter. The IAE video tapes were dubbed and the spacecraft was shipped to GSFC. After arrival at GSFC, the remaining portion of the experiment was deintegrated from the spacecraft and returned to L'Garde, Inc.

The Spartan Flight Support Structure (SFSS) that held the spacecraft in the payload bay, the Release/Engage Mechanism (REM), and the Spartan spacecraft carrier are in storage at GSFC for future flights.

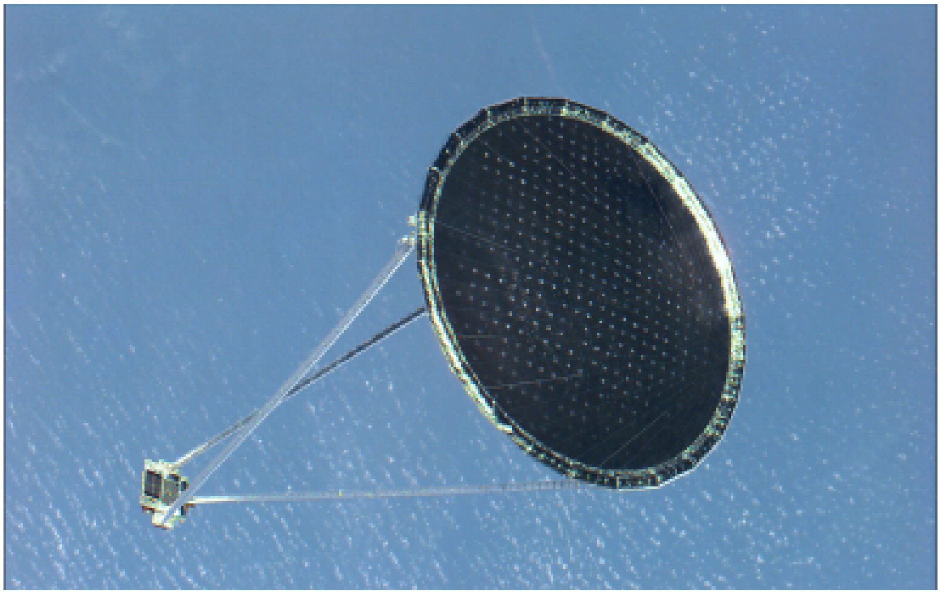
Overall the mission was very successful, and gained a great deal of information about inflating large structures in space. The experiment required a space environment to demonstrate the feasibility of large inflated structures because the required microgravity vacuum environment cannot be simulated on Earth at a sufficient scale. Although small models could be explored, not enough was known to validate the extrapolation of the small models to large structures. The Spartan free-flyer carrier provided the platform to carry the IAE into space, using the Space Shuttle to get to orbit, but flying free from the carrier's influences on the space environment. The Space Shuttle did prove to be an excellent platform from which to document the experiment, given its proximity to, but different vantage point from, the Spartan carrier. Also, having the astronauts in the loop during the data gathering process allowed greater flexibility to deal with the unexpected operations. The successful demonstration of a large inflatable structure in space has generated significant interest in the use of this promising new technology.

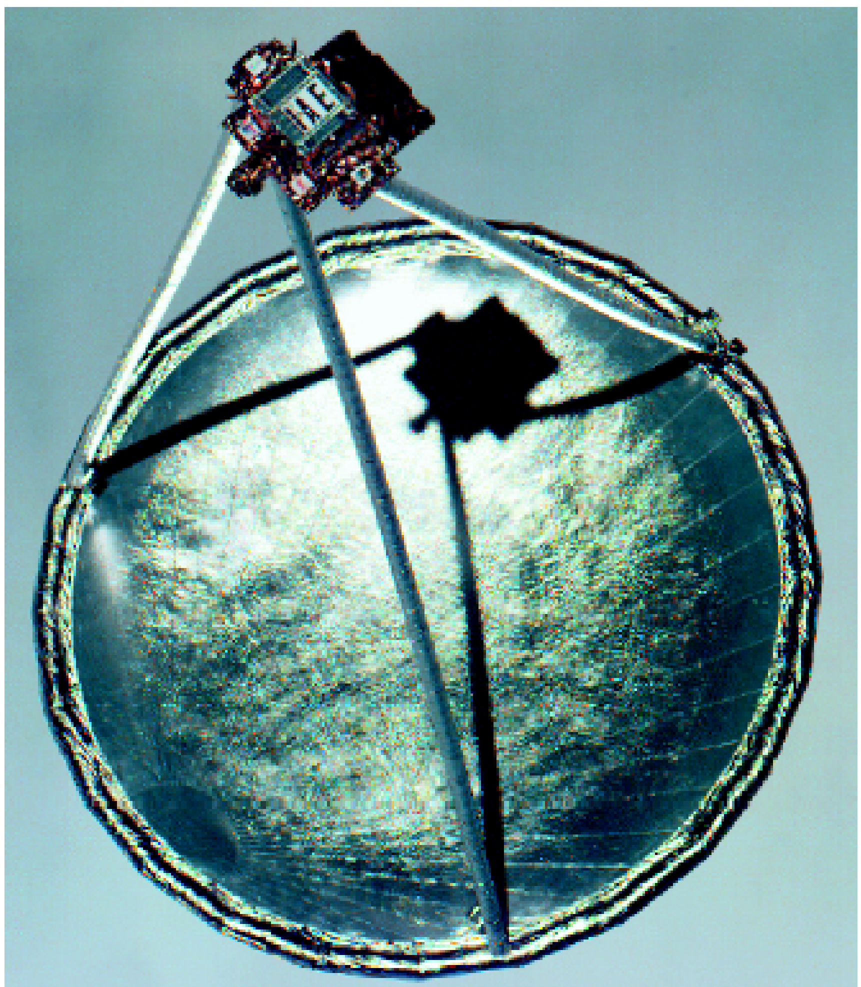
For more information on the Spartan 207/IAE mission, visit its Web page at:
http://sspp.gsfc.nasa.gov/sp207.html





Electronic still camera images of Spartan 207/IAE during experiment operations on STS-77.





Electronic still camera images of Spartan 207/IAE during experiment operations on STS-77.

Subsystem Performance

The following are brief status reports from the various spacecraft subsystems:

Mechanical:
The spacecraft was returned to earth in good shape mechanically. The four jettison posts operated as designed, including the firing of all eight pyros.

It should be noted that the cast aluminum nacelle on which the Electrical Flight Grapple Fixture was mounted, won its manufacturer, Nu-Cast of Londonderry, New Hampshire, a "Commitment to Excellence" award from the NASA New England Outreach Center.

Release/Engage Mechanism (REM):
Performance of the Release/Engage Mechanism (REM) was nominal during the STS-77 mission, as evidenced by on-orbit reporting by the crew and current traces of the motor's operation. Berthing of the Spartan in the REM on-orbit went smoothly and quickly. STS-77 was the third successful flight for the serial number 003 REM. Functional performance tests on the ground postflight were nominal.

Electrical:
The electrical system for the spacecraft worked nominally. The ACS Sync and BITE timers all operated as designed, with all commands being issued at the proper time. The Payload Genera Support Computer/Bus Interface Adapter (PGSC/BIA) communications terminal to the spacecraft continued to operate flawlessly.

Upon return to GSFC, the Solid State Recorder (SSR) data was duplicated and given a quick review for any obvious anomalies. The SSR contained the predicted amount of flight data and the SSR was tested for bit errors within and beyond the end of the flight data. Initial results indicate nominal SSR performance with error-free data.

The Spartan 207 battery was removed from the spacecraft for inspection and postflight analysis. There were no cell ruptures or any leakage whatsoever. The inside of the enclosure was dry and crystal free. Although it is normal for a minute amount of vent leakage, there was none. Postflight discharge of the cells indicated nominal cell performance with a consistent discharge curve for all the cells. The entire mission, including self discharge, used 253 amp hours of power, well within the expected budget.

Before it was deintegrated, the spacecraft underwent a functional Mission Simulation. The results were nominal for all systems capable of performing without the deployable antenna. The RF system performed perfectly during this test with an immediate signal lockup during the Mission Simulation, just as it did during the last preflight Mission Simulation. The problem with the RF performance is significant due to the lack of received video via the EMU-TV during the flight. Although there is no direct proof, the leading theory is that one of the inflatable struts moved into the field-of-view of the EMU-TV antenna during the unexpected dynamics of the inflation process, causing high reflected power to be introduced into the transmitter, shutting it down. This effect had been noticed on the ground preflight, but the movement of a strut in front of the antenna during free flight was not expected. No further investigation into this area is planned.

Spacecraft inspection revealed nominal pyro jettison and ACS valve activation with all pyros open as expected.

The flight data has been formatted into plots and specific sections for further analysis. All Payload Functional Control System (PFCS) related components appear to have performed nominally.

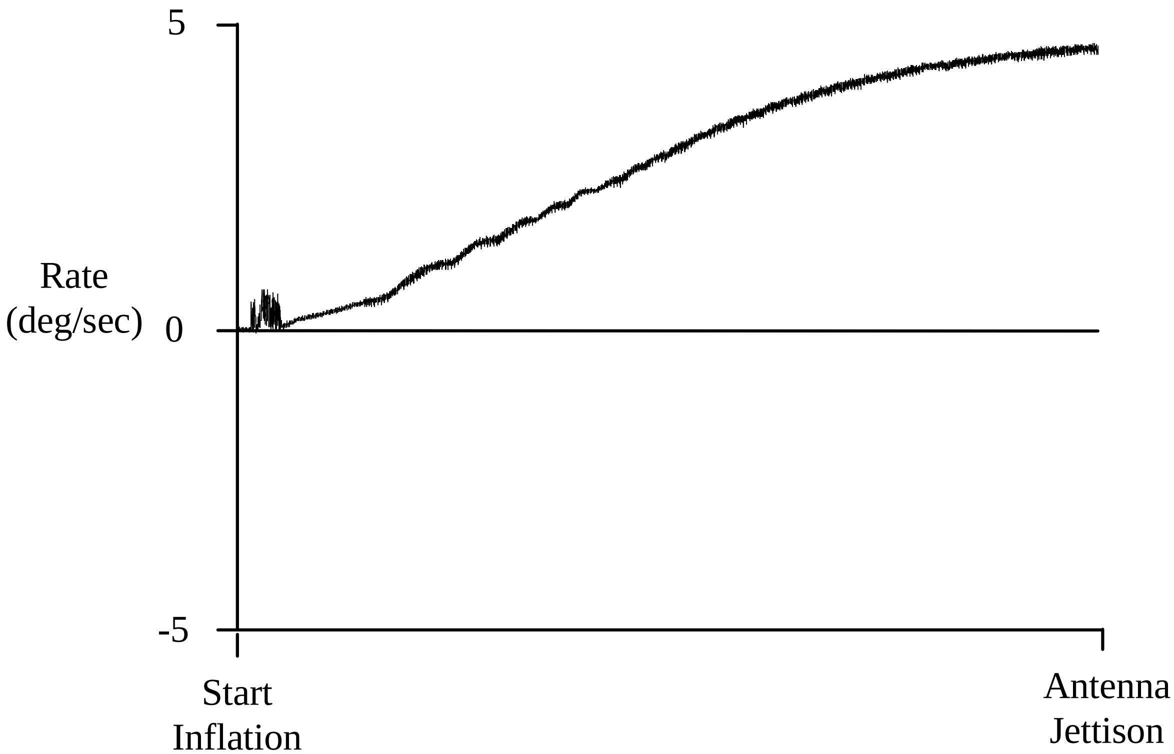
<u>Thermal:</u>
The thermal data indicate that the spacecraft components stayed within design limits.

<u>ACS:</u>
The ACS worked as programmed. Available data records from the solid state recorder indicate the limit cycle during the inflated portion of the flight was good. A complete report will be written once the position and rate data plus the valve operation records are analyzed.

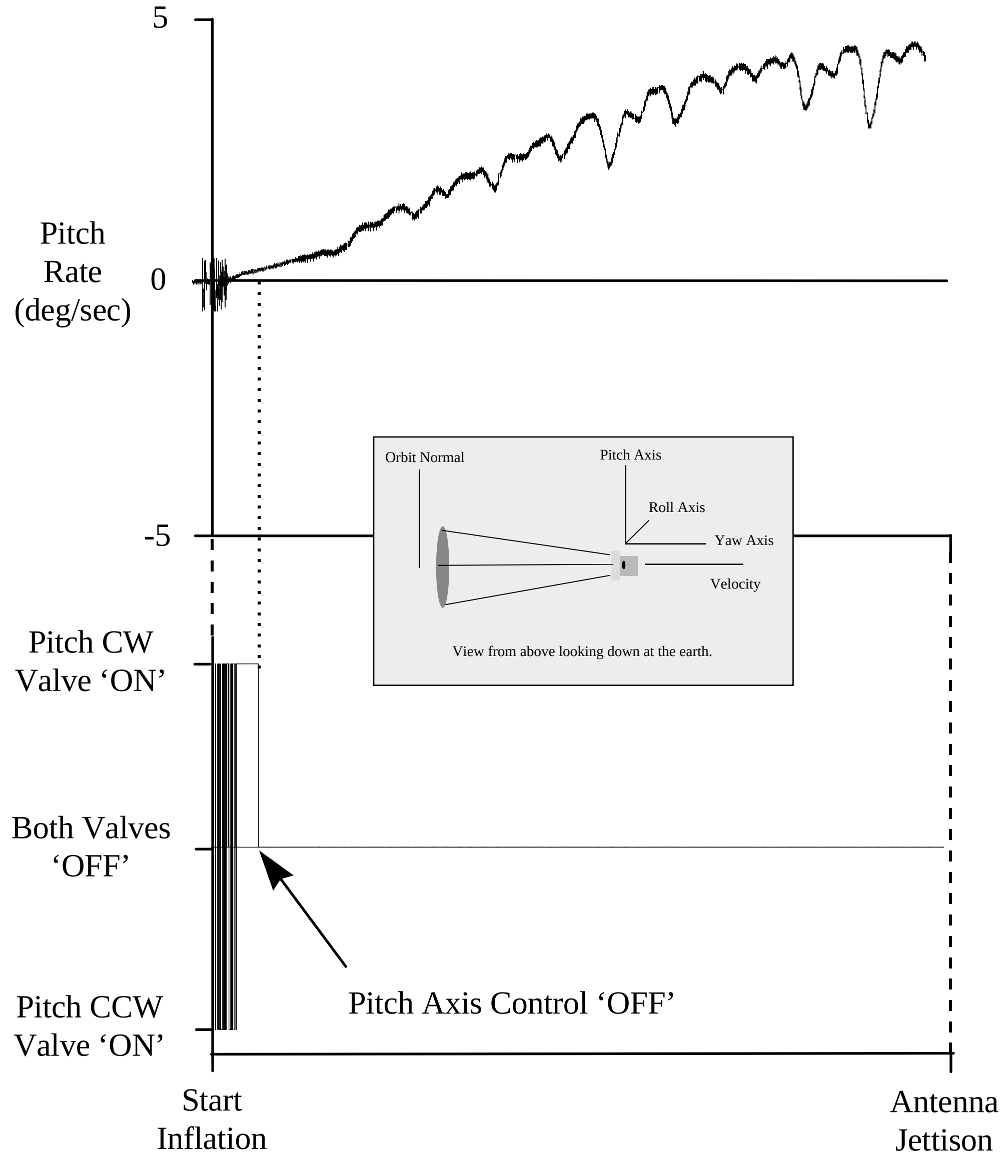
An analysis of the unexpected rotation of the spacecraft after inflation was prepared. The rotational rate throughout the mission was measured from the motion observed on flight video tapes and gyro rate measurements stored on the spacecraft's solid state flight recorder. The measurements were taken over an entire orbit, starting at the inflation and ending when the IAE was jettisoned. Both the video tape and gyro rate measurements agree. The rotational rate increased at a constant angular acceleration for the first half of the orbit before leveling off. This leads us to believe that the disturbance torque, present at the start, went away later on in the mission.

The following plots are of the overall rotation rate vs. time and of each axis along with thruster firing.

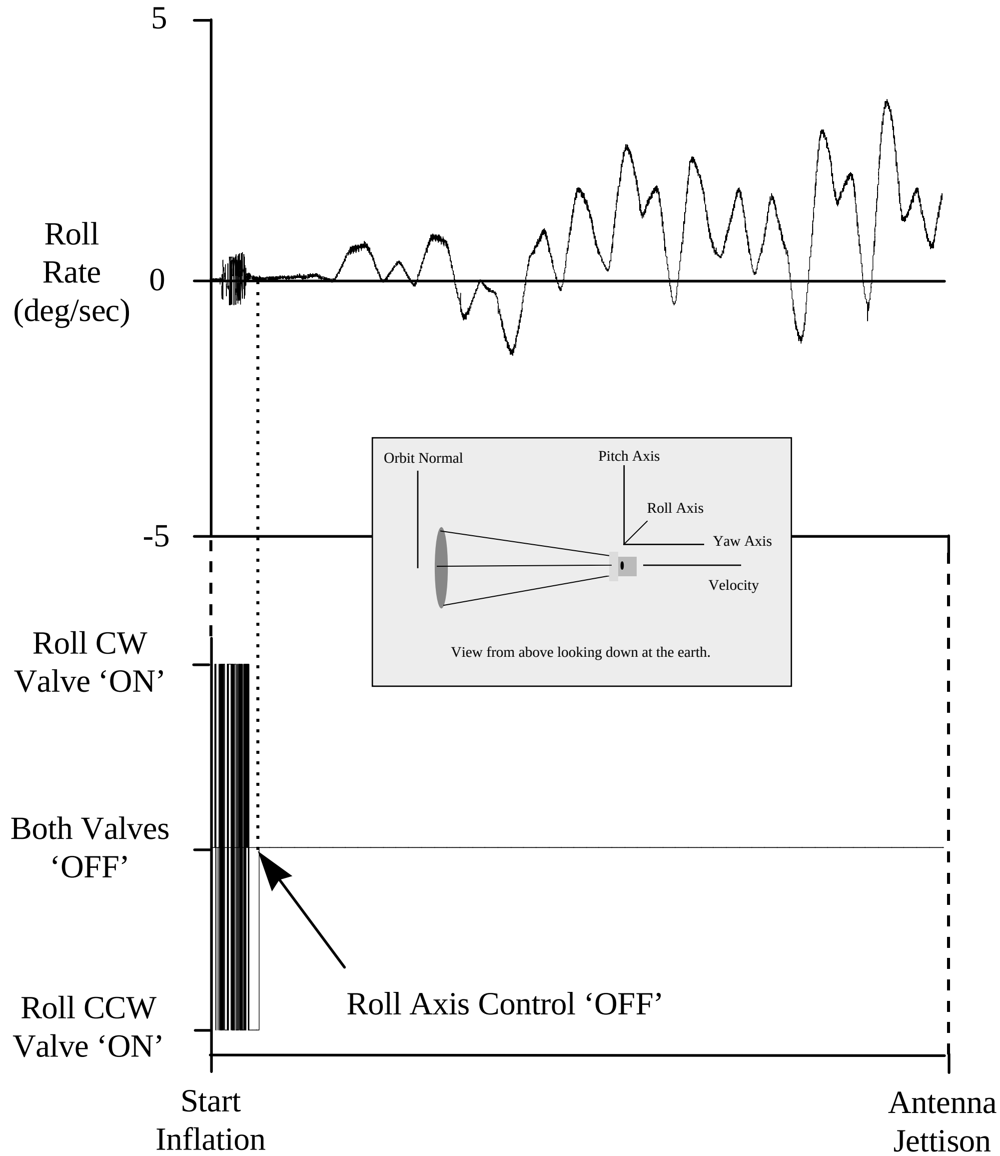
Combined Rate Plot



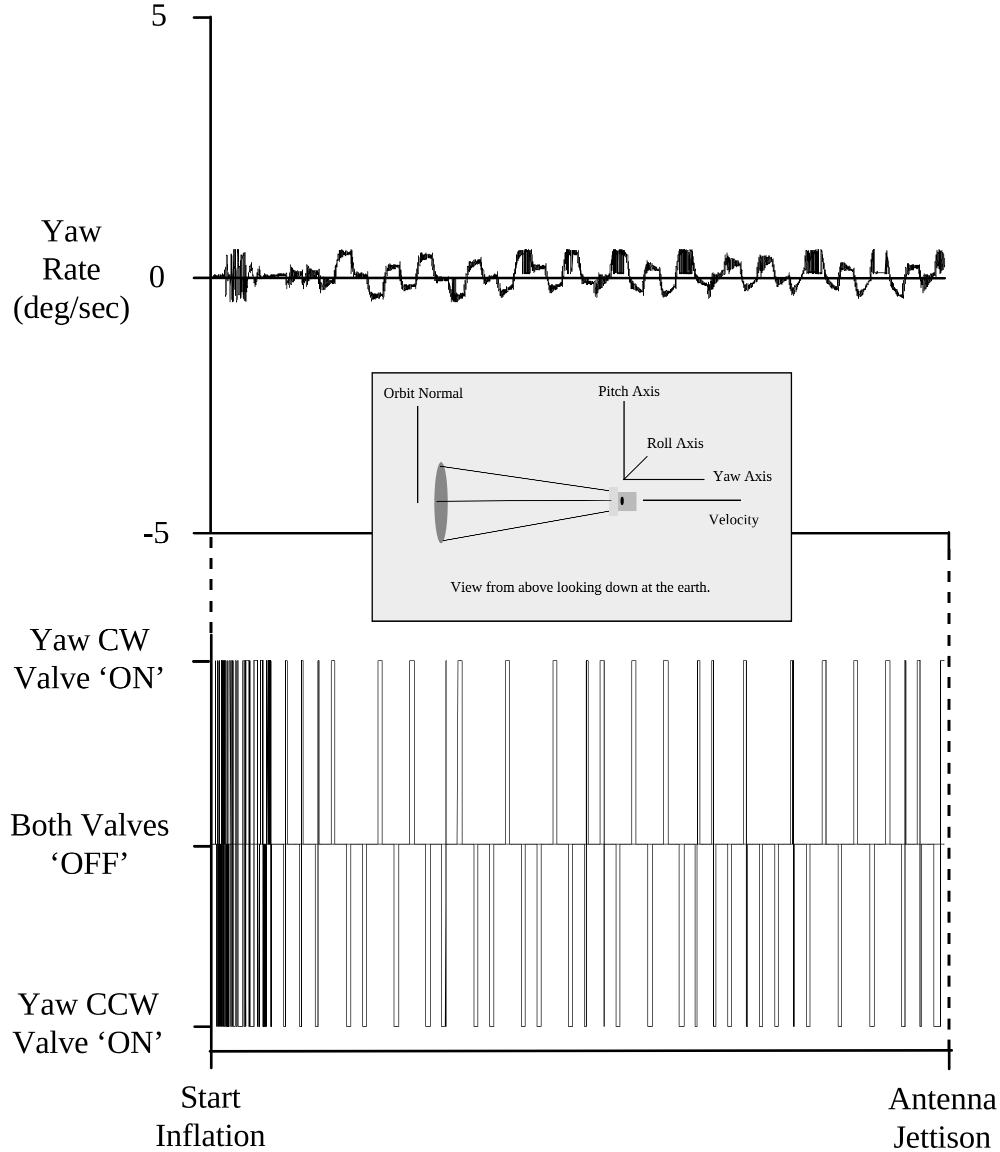
ACS Pitch Plot



ACS Roll Plot



ACS Yaw Plot


5
Yaw
Rate
(deg/sec)
0
-5
Orbit Normal
Pitch Axis
Roll Axis
Yaw Axis
Velocity
View from above looking down at the earth.
Yaw CW
Valve 'ON'
Both Valves
'OFF'
Yaw CCW
Valve 'ON'
Start
Inflation
Antenna
Jettison

Inflatable Antenna Experiment

1. Canister Operations

The canister doors and ejection plate deployment were initiated in the proper sequence and their articulations were near nominal.

2. Inflatable Structure Deployment Sequence

The inflatable structure deployment sequence was not nominal due to an unexpected amount of residual air in the stowed structure and a significant amount of strain energy release from the torus structure. This resulted in early deployment of the reflector structure such that the ejector plate was not able to propel it away from the canister. Consequently, when the struts deployed, they were not fully extended resulting in more strut deflection than anticipated. This also caused sequential rather than simultaneous strut inflation. However, as they completed deployment, the reflector was pushed away from the canister and deployment was completed.

3. Inflatable Support Structure Deployed Configuration

The inflatable support structure consisting of the torus and three struts deployed completely and maintained its nominal pressure of 3 psi. This structure appeared to be reasonably stiff in the deployed configuration. The robustness of this structural concept was clearly demonstrated on orbit.

4. Lenticular Structure Orbital Performance

The lenticular structure failed to completely deploy for unknown reasons at this time. Initially, it appears that the residual air in the stowed structure caused partial deployment, but subsequently that air escaped from the ascent vent holes and the lenticular structure went almost completely flat.

5. Surface Measurement System

The surface measurement system appeared to operate nominally. Due to the lack of proper inflation of the lenticular structure, a measure of reflector surface precision was not accomplished. However, the retro reflectors on the rim of the lenticular structure were clearly visible and the lateral motion of that structure across the camera field of view will be used to quantify the stiffness of the structure.

6. Photographic and Video Coverage From STS

The photographic and video coverage from the STS was outstanding. The deployment sequence was covered with both video and high resolution photography. The orbital dynamics of the deployed structure were also extensively documented.

7.	Engineering Data Recorded

Time histories of inflatable structure pressure and temperature, canister door, articulation position, ACS/magnetometer data and other engineering data were recorded on the Spartan and IAE. The IAE experiment tapes were duplicated and reviewed and found to be of good quality and expected recorded length

8.	IAE Electronic Control System

The electronic control system operated nominally with respect to initiation of functions, timing of events and multiplexing of engineering data.

Remaining Work

Work continues at L'Garde to determine exactly what happened to the antenna portion of the inflatable. ACS rate data, thruster firing information, and photo/video documentation will be analyzed and combined in this effort. GSFC engineers will be working with L'Garde as necessary to provide information on the spacecraft's behavior.

For further information, contact:

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