SAF Activities

Integration and test of the Galileo spacecraft is a complicated process that requires nearly as much time as the prime mission itself, to ensure a successful mission.

Completion of the spacecraft flight acceptance program is scheduled for October 1, 1984. Completion means that all design verification requirements have been satisfied, all functional and environmental tests have been performed, and all scheduled intersystem testing (mission operations system to spacecraft, spacecraft to Space Transportation System) has been accomplished. In short, the spacecraft could be committed to flight at that point.

Subsystem integration and test of the Galileo Orbiter began in JPL's Spacecraft Assembly Facility (SAF). The Orbiter subsystems are electrically integrated in SAF. Personnel wear “bunny suits” and follow special robing procedures to avoid electrostatic discharge.

Development Test Model

The Development Test Model (DTM) is the structural twin to the flight spacecraft being assembled in SAF, but it does not include the electronics or other flight equipment. It is used for testing to verify the structural analyses used in the design of the spacecraft.

Assembly of the DTM began in March 1983, and testing began in May. Tests include modal tests in the cruise and launch configurations, acoustic and pyro shock, and static tests.

The three-day cruise configuration modal test was completed on May 25. The object of this test was to look for natural vibrations of the spacecraft that affect the control of the spacecraft in cruise. The test was run to determine the key structural parameters. This information is then used by the
SAF Activities . . .

(Bldg. 179) in mid-March 1983. Contractors from across the country have been involved in developing and fabricating (building) pieces of the spacecraft. Before delivery to SAF, each engineering subsystem and science instrument has been tested, qualified, and accepted for flight. In SAF, these units are mechanically and electrically integrated to become a functioning spacecraft.

SAF consists of two environmentally-controlled clean rooms, the adjoining System Test Complex area, and office space. The Orbiter is being assembled in High Bay 2. The clean rooms are constantly controlled at 72°F and 50 percent humidity, and the air is cleaned with high efficiency particulate air filters. Special procedures eliminate the possibility of electrostatic charging of personnel and equipment that might come in contact with sensitive electronics.

Cabling from the spacecraft hardware in the clean room is routed to the System Test Complex, where engineers monitor and control the testing. (Visitors may view this area, but are asked to stand in the designated areas.)

Mechanical assembly and electrical integration of each flight-qualified subsystem into the Orbiter includes verifying the interfaces and functionally testing the subsystems as a unit while using Orbiter power, telemetry, and commands.

Orbiter subsystem integration and test will continue through this summer. The retropropulsion module (RPM) will be electrically integrated later this year. The remaining flight subsystems will also be integrated and tested this summer. In September, the Probe will be electrically connected to the Orbiter for the first time, and an end-to-end Probe data link test will be performed. This test will verify the overall data flow from the Probe to the radio relay hardware on the Orbiter, to the Orbiter command and data system, to the Orbiter modulation/demodulation system and radio transmitter, from the Orbiter to the Earth-based tracking systems, to the Orbiter and Probe ground data systems, and finally to the scientists for analysis.

The Probe will then return to Hughes for further environmental testing, and will be returned to JPL in January 1984.

Meanwhile, with all flight subsystems integrated and tested, Orbiter system tests will begin in October 1983. Baseline tests are run to accumulate data on the behavior of the Orbiter. The baseline test will be run repeatedly throughout the test program.

Interference tests will determine if any subsystem has any adverse effects on any other subsystems.

Mission profile tests will be performed to simulate activities for key mission phases such as launch, trajectory corrections, maneuvers, cruise, Probe release, and insertion of the Orbiter into orbit around Jupiter. Operational capabilities will be explored, to see what the Orbiter can do, in addition to what it must do.

System level testing of the combined Orbiter and Probe will begin in January 1984, followed by environmental tests next spring. The goal is final flight acceptance by October 1984. Shipment to Florida will be in January 1986 in preparation for launch in late May 1986.

Galileo's flight system integration manager is Dick Spehalski. Milt Goldfine is chief of test and operations, while Warren Moore is the deputy. Coordination is provided by the Project Test and Operations Section (374), with support from the technical divisions and the quality assurance organization.

Ultraviolet Spectrometer

The ultraviolet spectrometer onboard the Galileo Orbiter will study properties of Jupiter’s high atmosphere; the Galilean satellites Io, Europa, Ganymede, and Callisto; and the doughnut-shaped cloud of ionized plasma that surrounds Io.

Observations in the ultraviolet range of the spectrum yield composition information that cannot be obtained any other way.

The UVS will be mounted on the movable scan platform of the Orbiter, its aperture aligned in the same direction as the other remote sensing instruments (the imaging cameras, photopolarimeter radiometer, and near infrared mass spectrometer). Their data, taken together, will provide a comprehensive picture of many aspects of the Jovian system.

The UVS instrument's wavelength range of 1150 through 4300 Angstroms overlaps and extends the range available on the Voyager spacecraft and heightens the probability of discovering new ultraviolet phenomena.

Voyager measured a northern polar aurora on Jupiter that extended 30,000 kilometers. These auroras occur when electrons and ions spiral into the atmosphere along the planet's magnetic field lines that also intercept Io. The impact causes the dominant gases in the atmosphere — atomic hydrogen, molecular hydrogen, and helium — to light up. The intensity of the ultraviolet emissions is a
measure of the vertical distribution of the gases in the atmosphere.

Emissions over the planet as a whole occur because of sunlight and electron impacts. These "airglow" emissions can tell much about the structure of the upper atmosphere.

Galileo's UVS will look for complex molecules in Jupiter's atmosphere. Such complex molecules are destroyed by solar ultraviolet light, and the spectrum of scattered ultraviolet light is imprinted with a distinctive "fingerprint" of the molecule that was destroyed. Acetylene has been identified on Jupiter in this manner. It is important to identify such complex molecules to understand if complex hydrocarbons might be present on Jupiter. These hydrocarbons are the "building blocks" for life on Earth, and confirmation of their presence on another body in the solar system would have far-reaching implications.

During the Orbiter's twenty-month, twelve-orbit tour of the Jupiter system, it will map the Galilean satellites extensively. The UVS will look for evidence of atmospheres - an indication that volatiles are escaping from the moons and that their compositions are still evolving. The UVS will also search reflections from the satellite surfaces for evidence of ammonia, ozone, and sulfur dioxide. The UVS can measure hydrogen, oxygen, nitrogen, carbon, sulfur, calcium, lithium, magnesium, molecular nitrogen, nitric oxide, hydroxyl, carbon monoxide, cyanogen, and sulfur dioxide, as well as ions of molecular nitrogen, carbon monoxide, carbon dioxide, and magnesium.

Volcanic eruptions on Io are believed to be the source of a large doughnut-shaped cloud of ionized sulfur and oxygen that encircles Jupiter along the orbital path of Io. Temperatures of the sulfur and oxygen ions in this plasma torus can be more than ten times the temperatures at the surface of Io, and direct measurements of the ions

The ultraviolet spectrometer, developed and built by the Laboratory for Atmospheric and Space Physics at the University of Colorado, consists of a 250-mm Cassegrain telescope, a 125-mm monochromator, three photomultipliers, and control logic within an onboard computer. The instrument weighs about 4.2 kilograms and uses 4.5 watts of power. It scans one of three channels in the wavelength range of 1150 to 4300 Angstroms in 4-1/3 seconds, and its counters are read and data is transmitted to Earth at 1000 bps.

Principal investigator is C.W. Hord of the University of Colorado. Five co-investigators are members of the UVS team.

Development Test Model . . .

attitude control analysts in the mathematical model software which simulates the flight of the spacecraft in cruise.

For this test, the DTM was suspended from a crane and the spin and despun sections were separated as they will be in cruise (by about 3/16-inch) but prevented from spinning. Small exciters were used to vibrate the spacecraft, providing data on the natural frequencies and other structural parameters of the spacecraft. At this point, the DTM did not include the Probe, booms (science, RTG, magnetometer), high gain antenna, or adapters to the upper stage engine, and the propellant tanks were empty. The absence of these elements during the test is later analytically corrected for in the math model software.

The DTM is now configured for the six-week launch modal test from June 6 to July 25. All loads-carrying structures are identical to those that will be on the flight spacecraft. The high-gain antenna, Probe, and all booms are installed, and mockups of the science instruments and electronics simulate their mass. Alcohol and freon simulate the mass of the fuel and oxidizer in the retropropulsion module. The DTM with its adapters is attached to a base just as it will be attached to the Centaur upper stage. It is bolted to a seismic block - a block of concrete sunk about 14 feet into the ground to avoid interference from outside vibrations such as passing trucks - in the modal pit. (The pit is about 3 feet deep.) Again, exciters are used to vibrate the spacecraft to identify natural frequencies and other structural parameters. As many as 180 accelerometers and 350 strain gages will also supply data (in flight, the spacecraft will have only 6 to 12 accelerometers). This test data is used by analysts in the Applied Mechanics Technology Section (354) to verify the math model and launch loads predictions.

The DTM will next be moved into the Environmental Laboratory's acoustic chamber where it will be exposed to the noise levels the flight spacecraft will experience in the Shuttle's payload bay. Very large horns - about four feet on a side - will create an average of 147 decibels in the chamber, while microphones placed around the DTM will
From the Project Manager

It is personally exciting for me to follow the progress of integration and test of the flight spacecraft, as well as the DTM activities. Drop by the second-floor viewing gallery of High Bay 2 in SAF to watch the progress (the entrance is at the southeast corner of Bldg. 179). The DTM will also be available for viewing later in the summer.

Since then, work has steadily progressed on electrically integrating the engineering subsystems and science instruments. Where flight equipment is not available yet, engineering models or prototypes are being used for testing in order to uncover any existing design problems.

Integration of engineering subsystems through mid-June includes the spun and despun flight cabling; the flight power subsystem; the breadboard command and data subsystem (CDS); non-flight spun and despun structures; the attitude and articulation control subsystem (AACS) engineering development model, including the attitude control electronics (ACE), the despun attitude control electronics (DEUCE), propulsion drive electronics (PDE), star scanner, acquisition sensor, and linear boom actuators (LBAs); the flight radio frequency subsystem (RFS); and the engineering model modulation/demodulation subsystem (MDS). Science instruments integrated thus far include the dust detector subsystem (DDS), magnetometer (MAG), and photopolarimeter/radiometer (PPR).

Delivery of the Probe to JPL has been delayed about six weeks due to the discovery of contaminants in the data and command processor. The CDS and AACS integration has been hampered by late software deliveries and flight hardware fabrication problems. Planning is in progress to allow completion of the flight acceptance test program as scheduled by October 1, 1984.

Concurrently with buildup and test of the Orbiter, testing of the Development Test Model has begun. The cruise modal test has been completed, and the spacecraft is currently configured for the launch modal test. The acoustic and pyro shock tests will follow later this summer.

We also have a new program manager at NASA Headquarters. Harry Mannheimer comes to the program from Landsat. Former program manager Jim Staats is now the Deputy Director of NASA's Earth and Planetary Exploration Division.

— J. R. Casani

Development Test Model . . .

DTM in modal pit

pick up the noise levels. The acoustic tests will take about three days.

Pyro shock tests will require about two days. In flight, explosive bolts and cords will release booms, instrument covers, the Centaur, and the Probe. The shock waves from these explosions will be measured during the test to evaluate the effect of these pyrotechnic (gunpowder) devices on the rest of the spacecraft.

About the first of September, the DTM will be moved to the static test tower (Bldg. 280) for 10-weeks of static tests conducted by the Applied Mechanics Technology Section. Results of Shuttle flights to date, together with the Galileo mathematical model software, have been used to predict what the structural loads will be on the Galileo spacecraft. The test will be conducted to these predicted loads. Hydraulic loading devices (rams) will be used to pull on the spacecraft structure, and data will be accumulated through strain gages, load cells, and deflection transducers.

Frank Tillman is test manager for the DTM. Test directors for the individual tests are Marc Trubert, cruise and launch configuration modal tests; Dennis Kern, acoustic and pyrotechnic tests; and Jim Staats, static test.

Note to Galileo team members at JPL: To cut down on distribution costs, The Galileo Messenger is now being distributed to you through your Galileo Division Representative.

Meet the Team

Larry Colin wears many hats. He is the Chief of the Space Science Division at NASA/Ames Research Center, the Project Scientist for Pioneer Venus, and the Probe Project Scientist for Galileo. With Torrence Johnson, Galileo Project Scientist, he works to assure that the atmospheric scientific objectives of the Probe mission will be accomplished and that they mesh with the results to be gathered by the atmospheric measurements made by the Orbiter. At Ames, Larry works closely with the Galileo Probe Project Team, led by Joel Sperans, and with the Probe Principal Investigators. Here, spacecraft, scientific instruments and Probe mission planning all come together to yield a package that will provide in 1988 an hour of unique scientific data.

Larry's participation on Pioneer Venus, which began in 1971 and continues to this day, naturally led him to his current role with Galileo in 1977. Several of the Galileo Probe scientific instruments are descendants of those that flew on the Pioneer Venus Multiprobe Mission in 1978.

Larry obtained his BSEE degree from the Polytechnic Institute of Brooklyn in 1952, an MSEE from Syracuse University in 1960, and a PhD in electrical engineering from Stanford University in 1964.

Larry and his wife, Roberta, live in Palo Alto. Roberta owns and manages an employment agency with offices in Santa Clara, Palo Alto and San Mateo. Their son, Lee Edward, manages the Santa Clara operation, while daughter Lisa Maria is also employed in personnel work at a small firm in the "Silicon Valley."

Dr. Larry Colin