From the Project Manager

NASA has announced that Galileo will be launched in October or November 1989 from the Shuttle. Ulysses, therefore, will be launched in October 1990. The decision, announced jointly by NASA Administrator James Fletcher and European Space Agency Director General Reimar Luest, was “principally based on a desire to optimize the data return from these two important scientific missions. To delay Galileo until 1991 would have resulted in an additional two-year delay in beginning to receive prime data from the Jovian environment.”

We have been working with a fall 1989 launch as a baseline, and are very happy to have a NASA commitment to this date. However, this means we will be extremely busy over the next two-and-a-half years. The spacecraft sent to the Kennedy Space Center in December 1985 was prepared to be launched from the Shuttle aboard a Centaur, to study the asteroid Amphitrite, and to conduct a two-year mission at Jupiter beginning in 1989. In April 1989, we will send a very different spacecraft to the Cape for launch. Galileo (now back at JPL) is being reconfigured not only for changes in the mission, but also for changes in the launch vehicle, cruise science opportunities, and mission duration.

The VEEGA (Venus-Earth-Earth Gravity Assist) mission, because it sends Galileo much closer to the Sun, requires substantial thermal modification and testing to the spacecraft. Sun shades and new blanketing are being developed and a new battery of thermal tests is under consideration for this mission. Programmers are reworking the software to accommodate the complex VEEGA mission requirements. Another antenna is being built for addition to one of the RTG booms to enable communication with Earth while the existing antennas are pointed away for thermal control reasons.

The hardware which connects the spacecraft to its launch vehicle is also being redesigned and built. The Inertial Upper Stage (IUS) two-stage rocket will be used to boost Galileo out of low-Earth orbit.

With the VEEGA mission Galileo will take six years to reach Jupiter, and we will have a variety of opportunities for scientific study during cruise. Discussions are underway for possible science at Venus, at both Earth encounters, and at both passes through the asteroid belt. Three potential asteroid opportunities are being considered: Ausonia, Gaspra, and Ida (see the Table). The size and velocity (relative to the spacecraft) of the asteroid are both important considerations in choosing a target.

Finally, shelf-life and aging tests are an ongoing concern to the Project. The previous mission’s end-date was October 1990. With launch now in 1989, Galileo will be collecting data through 1998. Certain parts will need to be replaced or augmented to work effectively through that time.

We all have a lot of challenges ahead of us to complete the rework of the spacecraft and mission for the October/November 1989 launch date. With this firm commitment from NASA regarding Galileo’s launch date and the Project’s undeniable importance to the space program, we will be delivering a spacecraft which will return data Galileo Galilei never dreamed possible.

— J. R. Casani

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<th>Potential Asteroid Opportunities</th>
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<tr>
<td><strong>Asteroid</strong></td>
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Net Flux Radiometer —
Studying the Atmosphere

Pioneer and Voyager spacecraft passing by Jupiter measured radiation leaving Jupiter's cloud tops, but we can only theorize about the nature of radiation within the atmosphere. In contrast, the net flux radiometer (NFR) in the Galileo Probe will directly sample the local radiation flows within and below the Jovian cloud layers.

Probe Descent

As the Probe descends through various atmospheric layers, there will be observable changes in the net radiation flux. These changes will reveal the driving forces for atmospheric motions: If more radiation enters a layer than leaves it, that layer is radiatively heated, and other layers are radiatively cooled. The temperature differences that tend to arise from the radiative heating and cooling produce buoyancy differences and, ultimately, atmospheric motions. Identification of such layers, and the magnitude of the heat deposited or lost, will comprise the fundamental measurements of the NFR.

Composition Analysis

A second major objective of the NFR is to help identify components of the Jovian atmosphere. The vertical profile of net radiation flux will show dips in regions where the atmosphere absorbs radiation relatively strongly. Furthermore, the NFR will measure dips (which are increases in opacity) with several spectral bands. The magnitude of such dips can be correlated with the temperature and pressure measurements of the Probe's atmospheric structure experiment and with the particle backscatter measurements of the nephelometer. Together, these three data types will provide significant constraints on the nature of the atmospheric material causing each region of greater absorption.

The NFR uses a rotating optical head in which detectors view a 40-degree cone of atmosphere through a diamond window. The viewing cone is centered at a 45-degree angle as the most representative angle for estimating the integrated energy from an entire hemisphere. A horizontal rotation axis allows both upward and downward hemispheres to be viewed by the same optics and detectors. During the descent into a continuously hotter and denser atmosphere, the NFR will rapidly help identify various atmospheric species.

It is well established that molecular hydrogen is the major source of gaseous opacity in Jupiter's atmosphere. However, hydrogen has "windows" or "holes" in its spectrum through which the atmosphere would lose tremendous amounts of radiation to space were it not for the minor constituents of methane, ammonia, and water vapor that fill the holes in the hydrogen spectrum. By measuring the net flux as a function of altitude in the hydrogen windows, it is possible to estimate the abundances of the trace gases. This provides a crude backup alternate between looking upward and downward. Measuring the difference in radiation intensity between these two views will determine the magnitude and direction of the net flow (net flux) of radiative energy.

Behind its single diamond window, the NFR has six lithium, tantalate, pyroelectric detectors viewing through filters extending from the visible to infrared wavelengths. One filter is used to measure the deposition of solar energy, while a second is used to measure the integrated infrared energy flux. Three additional spectral regions were chosen to some of the mass spectrometer measurements. More directly valuable are the measurements of opacity contributions by particulates within the atmosphere. The location of cloud layers by their effects on infrared and visible opacity also provides a partial check on the cloud particle observations of the nephelometer.

Optical Comparison

Because the net flux during descent becomes very small compared to the total energy flux, there are severe requirements on optical symmetry between upward and downward views (the classic
problem of subtracting two large numbers applies here). To ensure that detector illumination and window characteristics don't change between upward and downward views, the entire optical system is rotated as a unit to obtain the two views.

In addition to the net flux measurement, the NFR also measures, every other minute, the upward atmospheric flux and the flux from an onboard blackbody. The onboard radiometric calibration system is used to monitor system performance during descent. In the net flux mode, the NFR looks up and down twice per second. In the calibration mode, the NFR flips between two internal radiation sources: a blackbody at ambient temperature and a hot blackbody at a controlled temperature of 410 kelvins. In the up-flux mode, the NFR flips between viewing downward and viewing the heated target.

In each mode, the net flux signal is integrated for 5.5 seconds and sampled every 6 seconds. In each two-minute NFR cycle, there are 20 six-second instrument cycles, of which 17 are devoted to net flux measurements, and one each to up-flux measurement, blackbody measurement, and analog zero check. This same data format is used throughout the descent, providing a vertical resolution of about 1.2 kilometers (0.74 miles) while the Probe is descending rapidly, and a gradually finer resolution as the descent rate slows. At a level of pressure 10 times that at Earth’s sea level, the vertical resolution will be about 0.2 kilometers (0.12 miles).

The NFR has a mass of 3 kilograms (6.6 pounds) and will use an average of 10 watts during descent. It was built by Martin-Marietta Denver Aerospace. The principal investigator is L. Sromovsky at the University of Wisconsin (Madison). Other team members are H. Revercomb (also at Madison), J. Pollack at Ames, P. Silvaggio and J. Hayden at Martin-Marietta in Denver, and M. Tomasko at the University of Arizona (Tucson).

— Roger V. Carlson

Aging: Its Effect on the Spacecraft

The aging of the Galileo spacecraft’s parts is a pressing concern to the Project. Just as any piece of equipment has a certain expected lifetime of operation, so too batteries, paints, and rubber parts will wear out or age after a short while. With Galileo’s arrival at Jupiter delayed another six years, some of these parts will be at or beyond their expected lifetimes.

There are a variety of areas being studied for possible aging effects. Some of these include degrading flexibility of cable coverings, losing adhesion on conductive tape, corroding or rusting of various metals, aging and chemical change of paints and coatings on the spacecraft, and fracturing of O-rings. The solutions to these concerns are as varied as the parts themselves.

The spacecraft is very sensitive to temperature, humidity, and magnetic fluxes, and suitable precaution is exercised in the “clean room” in the JPL Spacecraft Assembly Facility, where Galileo will be stored until shipment to the Kennedy Space Center. Even so, exposure to the atmosphere may corrode some of the magnesium alloys used on the spacecraft. (Such metals would not corrode in the vacuum of space or within Galileo’s original lifetime.) Quality assurance personnel will visually inspect all surfaces before shipping the spacecraft.

In the case of the paints on spacecraft parts, periodic visual inspections are conducted to verify that the paint is not flaking, cracking, or peeling. So to, some of the coatings on spacecraft parts may shrink over time, damaging the parts they were used to protect. Both uralane and humisal conformal coatings on the electronics are being studied and monitored to avoid any damage. Reliability tests will continue on the electronic parts themselves to verify their continued effectiveness.

Fracturing of O-rings occurs after long-term storage and dis-use. To circumvent this potential problem, engineers will “exercise” all parts containing O-rings every six months.

Springs, which were compressed for release of systems such as the magnetometer boom, may suffer degradation after such long storage. All preloaded springs will be inspected for signs of stress.

A further problem involves the tests themselves. Personnel will need to handle the spacecraft to conduct the tests, and this contact may add dirt to surfaces or overstress flexible parts. Visual inspections and testing care will be ongoing to avoid this dilemma.

As the Probe descends through the atmosphere, the Net Flux Radiometer (NFR) collects data to determine cloud layer location and atmospheric-constituent mixing at various altitudes. The NFR is located on the equipment shelf periphery to allow the optical head to extend through the Probe’s aerofairing.
Meet the Team

Probe Operations Office Chief Benny Chin is a commuting member of the Galileo team. He divides his time between his home base of the Ames Research Center and roughly one day a week at the Jet Propulsion Laboratory.

During some quiet moments between a project review and the flight north, Benny outlined the biggest jobs his office is dealing with now. They all stem from rescheduling the mission. For example, choice of the VEEGA trajectory means that new system studies must be done to check for any heat problems when the spacecraft approaches the orbit of Venus. Sequences of activities must be changed. Finally, and most importantly, the shelf life of all the parts must be checked. “A lot of these things were built prior to 1980, and we’re looking at a baseline 1989 launch plus a six-year mission!”

Getting these jobs done means that studies must be made by scientists at a lot of sites. Coordinating those studies requires a lot of travelling. Fortunately, Benny has grown accustomed to such travelling. He has been doing spacecraft testing and operations for Ames since 1968, first with Biosatellite, Pioneer Jupiter, and then with Pioneer Venus. During that time he has been involved in seven launches. Before becoming Probe Operations Chief in March 1986, he was involved in integration and test of the Probe, and he was at Kennedy Space Center preparing for launch.

Benny ascribes much of his ease with travel to growing up in the New York City area (mostly East Orange, New Jersey). Getting away from that small world started with an aerospace bachelor’s degree at Virginia Polytechnic Institute and continued with a two-year stint at the Pacific Missile Range, 21 years service at Ames, and an MBA from Golden Gate University.

A second match with the job is in dealing with people. The soft-spoken Probe “Ops” Chief enjoys “getting out and interacting with people,” a key part of running a scattered operation. He even commented that sitting behind a desk five days a week would probably not be enjoyable for him.

Integration and testing and operations have been the main parts of Benny’s career at Ames (“with steadily rising levels of responsibility”). In his words, “I just fell into it when I arrived, and I liked it.” When asked about a goal ten years in the future, the answer came with calm assurance: “We will have completed this mission and be into another one, either in operations or management.”

Benny lives in Saratoga (west of San Jose) with his wife Winnie and two children, Kristen (10) and Matthew (7). Other than a little skiing in the Sierras, his main hobbies are “... taking care of the kids.”

— Roger V. Carlson

* Editor .................................. Jeanne Collins

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