The greatest challenge in getting Galileo to Jupiter has been met. In less than four months, the Flight Team expertly conducted the inflight spacecraft checkout and characterization, including all the science instruments, and navigated Galileo to a perfect Venus gravity assist (the “V” in VEEGA) on February 9. And, Galileo flew through perihelion—the closest it will ever come to the Sun—on February 25, with no temperature problems.

We are now on a trajectory to Earth that sets up the first of our two Earth gravity assists (EGAs). The heliocentric (Sun-centered), Earth-return trajectory produced by the Venus gravity assist has already established the 9 kilometers/second Earth-relative speed needed to reach Jupiter. However, the direction of this first Earth approach (the Earth-relative velocity) is roughly perpendicular to the Earth’s velocity around the Sun. The purpose of our two EGAs is to turn this Earth-relative velocity about 90 degrees so that it adds directly to the Earth’s 30 kilometers/second tangential velocity around the Sun. Galileo will then be traveling 39 kilometers/second tangential to Earth’s orbit. A spacecraft moving 39 kilometers/second tangential to the Earth’s orbit will have its aphelion (its farthest distance from the Sun) three years later tangential to Jupiter’s orbit.

The Venus flyby was excellent. Some innovative techniques were used to receive three of the 81 Venus images a few days after the flyby; all of the Venus data are stored on Galileo’s tape recorder and will be transmitted to Earth this November. While Galileo is flying inside Earth’s orbit (closer to the Sun than the Earth is), we must keep the high-gain antenna (HGA) furled and its tip shade pointed at the Sun so that sunlight does not strike the HGA. Consequently, the HGA is unusable. Therefore, we must wait until Galileo is approaching the Earth, when the short communication range will allow us to transmit the Venus data over one of Galileo’s low-gain antennas at a standard tape recorder playback rate.

The Venus images and other science data we will receive in November will be very exciting. Galileo collected some science no other spacecraft has ever cap-

-Venus' upper clouds show details as small as 25 miles wide, while other clouds rise from lower levels in the atmosphere. These images were taken two hours apart on February 12, when Galileo was about one million miles past Venus.
Galileo—Up To Date

The Galileo spacecraft has successfully completed its first planetary flyby—with Venus. The main objective of the flyby was to change the spacecraft’s trajectory and increase its velocity by roughly 5000 miles per hour to help ensure its arrival at Jupiter in 1995. This was accomplished, making the flyby a resounding success! As an added scientific benefit, all of Galileo’s Orbiter instruments collected scientific data on Venus and its environment.

Because the spacecraft can only use its low-gain antennas—the high-gain antenna is still furled to protect it against the Sun’s heat—just a few images from the flyby have been returned. Matt Landano, Deputy Mission Director, explained: “We developed a special tape-recorder playback technique that allowed return of this information at a rate of 1200 bits per second (bps), whereas Galileo would normally be sending science data at no less than 7680 bps. The new technique requires about 3.6 hours to receive one image. Despite the return of just a few images, the atmospheric scientists are elated by the quality of the images, the atmospheric scientists reconfigured the spacecraft to a new technique requires about 3.6 hours to receive one image.

One-Way Light Time

Velocity Relative to the Earth

Velocity Relative to the Sun

Spacecraft—Sun Angle

Spacecraft Spin Rate

Downlink Telemetry Rate

Spin Configuration

Powered Science Instruments

RTG Power Output

*All information is current as of March 30, 1990.
Networking Out of This World

Four spacecraft fly to the cold reaches of interstellar space, dozens orbit in a frantic pace around the Earth, others fly to and orbit the planets, and Galileo continues its roller coaster ride through the solar system. What do all these missions have in common? The only ear that can hear all their voices belongs to NASA's Deep Space Network (DSN).

Spanning the globe, from Goldstone, California, to Madrid, Spain, to Canberra, Australia, three Deep Space Communications Complexes (DSCCs) listen in on all this space chatter and transmit it on to the scientists and engineers working in ground support and on the project teams for the various spacecraft. Each DSCC has four very large antennas (one 26 meters, two 34 meters, and one 70 meters in diameter) that can pick up faint signals from space. Each of these antennas has a specialized function. For example, the 70-meter antennas can retrieve very faint signals, while the 26-meter antennas are best for tracking launches or Earth-orbiting satellites since these smaller antennas can move quickly across the sky, keeping pace with the satellites. The 26-meter antennas will be used during Galileo's Earth encounters.

Until the Venus flyby, the DSN was devoting about 30% of its time to the Galileo mission. This commitment will decrease during the quiescent cruise time, will increase slightly during the two Earth encounters, and will increase dramatically as Galileo approaches Jupiter and enters the satellite tour phase of the mission.

Although the DSN devotes some time each week to maintaining the DSCCs, unique dilemmas occur now and then. For instance, just after Galileo's launch, an elevation bearing under Madrid's 70-meter antenna failed and put the antenna out of service. According to Douglas Mudgway, Tracking and Data System Manager for Galileo, "This occurred suddenly and without warning. It required a major effort over several weeks to repair because of the enormous loads on the bearings—each bearing carries half of the 4,200,000-pound antenna load." The cause of the failure at this point is unknown, but the DSN engineers are continuing to analyze the problem to prevent its recurrence.

Another interesting situation developed during the Venus encounter, when high winds in the California desert necessitated shutting down the Goldstone site. The Canberra Complex had to come on about four hours early to support Galileo's needs.

Galileo poses some unique challenges to the capabilities of

—see page 4

The DSN's antenna complexes, located around the globe, can always keep one antenna pointed toward Galileo.
In Australia, Canberra's 70-meter antenna picks up Galileo's faint signals from space.

(NETWORKING from page 3)

the DSN. Because of thermal considerations, Galileo's high-gain antenna (HGA) must be shielded behind its sun shades until the spacecraft is at a safe distance from the heat of the Sun. As a result, only the low-gain antennas can be used, and even they cannot be pointed ideally toward the Earth. Until the HGA can be used in May 1991, DSN support is greatly complicated, but has been outstanding in all respects, according to Neal Ausman, Galileo Mission Director.

In a recent tour of the DSN sites by Galileo Project management, Mudgway noticed that interest in the Project was high, not only at the DSN sites, but also throughout the local community.

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In a recent tour of the DSN sites by Galileo Project management, Mudgway noticed that interest in the Project was high, not only at the DSN sites, but also throughout the local community.

“People find it difficult to imagine that a [planetary] spacecraft so soon after launch is down to a data rate of 40 or 10 bits per second (bps) on the 70-meter antennas. This is very unique. Normally you would expect a 1200-bps rate or higher.”

When the spacecraft reaches Jupiter, it will be at its maximum distance from the Earth and the DSN’s antennas, unavoidably degrading the performance. To compensate, several plans of action are possible. First, the DSN can “combine” the data-gathering capacities of all the antennas at one site to enhance their function. Second, the DSN plans to develop new coding and decoding schemes by May 1991, which will allow more efficient reception of the data from Galileo. Finally, the Network will continue to evaluate several alternatives to improve antenna performance, including the use of other non-DSN facilities, although, according to Mudgway, “The DSN is almost at its theoretical limits for deep-space telecommunications like this.”

Meet the Team Leader in the OET

For those not intimately associated with the Galileo Project, it might seem as if the spacecraft flies its complex trajectory effortlessly, collecting images and data as it heads toward Jupiter and its place in history. However, Galileo is only a sophisticated machine that follows the commands of the Galileo Flight Team. The Orbiter Engineering Team (OET) creates these commands and oversees the engineering operations of the spacecraft, making sure it remains safe, and using Galileo's resources wisely. This Team is led by Team Chief Robert Kocsis.

In overseeing the OET, Rob makes sure the spacecraft is kept healthy so that the mission objectives can be realized and the science teams on the Project can satisfy their objectives. He and his Team maintain the health of the spacecraft by monitoring the engineering data (the temperatures, pressures, voltages, and currents), calibrating the equipment, ensuring safe operation within the current capabilities, and watching over the lifetime limits of each piece of hardware. By running tests and looking for any changes over time or deviations from expected values, the OET can determine trends and identify Galileo's unique characteristics. As the mission progresses, the OET learns to assess
Galileo’s capabilities and develops an understanding of its responses.

Nearly 100 people comprise the OET, and Rob is supported by three deputies: Arden Accord, in charge of real-time operations, Pete Kobele, leading the analysis group, and Dave Durham, supervising the uplink design. The efforts in each group vary with time.

As the mission has progressed, Rob observed, “We have used the real-time commands more than anticipated. We didn’t account for the amount of effort required and some of the surprises Galileo had in store. Oddly, we’ve had a hard time finding stars, mainly due to the VEEGA trajectory and thermally based pointing constraints on the spacecraft. We have an expectation of how the stars should be perceived by the spacecraft, but how it really works can be something entirely different.”

In his work, Rob interfaces with the Galileo Project, reviews technical issues and strategies, works with other teams comprising the Flight Team, and coordinates the three OET areas, monitoring the Team’s overall efforts.

While enjoying the technical challenges in his work, he is most fascinated by the people he interfaces with. A true fan of Galileo, his pride is echoed throughout his Team, “This marvelous spacecraft is incredibly complex and works extremely well. However, even though you think you understand it, you may not. You have to be very careful and constantly keep learning. But, we have never done much with any other spacecraft so soon after launch.”

Rob came to JPL in October 1966 from Brown University in Providence, Rhode Island, with a bachelor’s degree in aeronautical and astronautical engineering, specializing in fluid mechanics and thermodynamics. He started in Division 35, where he designed mechanical devices for Mariners ’69 and ’71. During that time he finished his thesis and received his master’s degree in 1968. He then moved on to systems engineering and fault protection for the Viking mission, working at the Cape for both Viking launches, and performing real-time operations through the landings on Mars. Later, he supervised the advanced designs group in Division 35.

When he’s not leading the OET, Rob enjoys hiking in Griffith Park with the Sierra Club and biking throughout Southern California, photographing people and nature. He and his wife, Patricia, have two sons, Jonathan at U.C. Santa Cruz and David at New York State, who with their father enjoy ice hockey and basketball. On a warm summer’s night, you might catch Rob and Patricia listening to Mozart, Bach, or Al Jarreau at the Hollywood Bowl, still keeping an eye on the spacecraft. *

**Editor’s Note**

The new Galileo Project Manager is William J. O’Neil, following Richard Spehalski’s move to the Space Infrared Telescope Facility project.

Bill has been involved with the Galileo Project since its inception. Coming from a strong background in mission design and navigation, Bill had been Galileo’s Science and Mission Design (S&MD) Office Manager since 1980. During the development phase, the S&MD Office was responsible for mission design, all interfaces with the scientists, and development of the Orbiter’s science instruments.

Bill studied aeronautical engineering, receiving a bachelor’s degree from Purdue and a master’s degree from the University of Southern California. Since joining JPL in 1963, he has worked on the moon lander Surveyor, the Mariner Mars 1971 orbiter, and the Viking Mars landers and orbiters. He was Manager of the Mission Design Section before joining the Galileo Project.

Bill and his wife Diane live in Sierra Madre and have three adult children. Last year was a banner year for the O’Neils: in addition to the launch, all three of their children moved back to Sierra Madre, the oldest and his wife bringing Bill and Diane’s first granddaughter. Although they enjoy traveling and downhill skiing, on some weekends Bill can be found looking after their real estate investments—painting and fixing plumbing in their “mom and pop” apartments. *

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*The caption for the image of Venus on page 4 of issue 22 of The Galileo Messenger erroneously read: “Earth-based images, like this one, show little detail in Venus’ clouds, . . . .” Actually, the image was taken by the Mariner 10 spacecraft, and in fact showed a good deal of detail. My apologies._-Editor*
For the Flight Team

As Galileo was being deployed from the Space Shuttle Atlantis, Commander Don Williams said, "...Galileo is on its way to another world. It is in the hands of the best flight controllers in this world."

His comments were very flattering and in my opinion 100% correct. The Galileo Flight Team has done an absolutely outstanding job. In slightly less than four months, the Flight Team has participated in a flawless launch and deployment, a reconfiguration of the spacecraft from launch to cruise mode, and a characterization of the spacecraft, including its science instruments. The members of the Flight Team promptly diagnosed the cause for Galileo's entry into fault protection, and then carefully and methodically reconfigured the spacecraft to a state compatible with that required at the start of EV-6.

During the Venus encounter sequence, the Flight Team correctly diagnosed a sequencing problem in a matter of hours, allowing the Solid-State Imaging instrument to be turned back on and to complete the balance of its planned data-gathering sequence. The Team also generated and transmitted several last-minute commands thermally controlling the Near-Infrared Mapping Spectrometer to assure it was able to acquire meaningful data from Venus. All the while, the Team was dealing with an unexpectedly difficult star selection process required to keep the spacecraft properly oriented.

The Galileo Flight Team has responded professionally to every challenge and has willingly devoted hours of overtime to achieve a spectacular start to the mission. I am proud to be a part of the Galileo Flight Team. It is composed of exceptionally talented, completely dedicated people—you are the best flight controllers in the world. *

—Neal E. Ausman, Jr.
Galileo Mission Director

So Long . . .

As of February 26, command of the Galileo Project was turned over to Bill O'Neil and I moved on to be the Project Manager of the Space Infrared Telescope Facility.

My memories of twelve years on the Galileo Project are varied, just as I am sure are yours. We have endured times that were challenging, as well as threatening, and we have enjoyed success. Your performance in the years before launch, as well as the months of intense activity culminating in an outstanding Venus encounter, has been superlative. We all are elated and take pride in the successes we have shared. But, the real excitement is yet to come.

Godspeed!

—R. J. Spehalski

* Construction is nearing completion on a full-size replica of Galileo, using the Development Test Model and spare parts, in JPL's Spacecraft Assembly Facility, Building 179. This replica will allow us all to appreciate the full-scale details of Galileo's actual mission configuration and will let us show a magnificent replica of Galileo to others.

We are now preparing our observing plans for the first Earth-Moon encounter in December 1990 and for the Asteroid Gaspra encounter in October 1991. Following our Gaspra encounter, and in concert with our final Jupiter tour design, we will decide in June 1992 whether to also perform an encounter with Asteroid Ida in August 1993.

The Venus flyby was a great achievement for all of us in quickly understanding the spacecraft's subtleties and dealing with surprises. I'm amazed and impressed by what we have accomplished in these first six months. It is my honor to be associated with such an outstanding team and with the most exciting planetary mission for the balance of this century. *

—Bill O'Neil