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Smooth landings

JPL wins New Millennium mission Space Technology 9

By Mark Whalen

Crew members inspect the sounding rocket used for a Space Technology 9 test mission at White Sands Missile Range, N.M. At center is JPL's Paolo Bellutta, who served as the lead experiment engineer for the JPL equipment flown on the mission.

In an effort to help future NASA missions land safely at more desirable but potentially perilous locales, JPL will develop a prototype of an automated, onboard system to enable pinpoint navigation along with the detection and avoidance of hazards during a spacecraft's descent to the surface.

Through a series of flights using the New Mexico desert as an analog for deep-space outposts, the project, Space Technology 9, is the newest in NASA's New Millennium Program to test leading-edge technologies and reduce their risk for future spaceflight.

"We want to give the science community the ability, in the future, to send robotic spacecraft to new and scientifically interesting places that we can't go to right now because it's too dangerous from an engineering standpoint," said Project Manager Sam Thurman.

"Inevitably we will want to go to a place that's scary in terms of trying to land. Our system will allow a spacecraft to see where it's going, recognize features you might want to go to and take you there while recognizing hazards that should be avoided."

In this extended Phase A study, the project team is working to replan its schedule and budget, as directed by NASA Headquarters, by the end of July. "We believe we can achieve NASA's goal of a 40 percent cost reduction," Thurman said, adding that pending Headquarters approval to go forward, the project would start in fiscal 2008.

The original proposal called for four different suborbital flight test missions and three major field test campaigns. The new plan, Thurman said, includes three such flight tests, the first of which would be in 2008 and the last two in 2011. A single field test campaign would be conducted in parallel with preparations for the 2008 flight test.

At the heart of the project is the terrain-relative guidance system, which integrates computer vision and inertial sensing to perform terrain-relative navigation, hazard detection and landing-site targeting.

"This is the Holy Grail," Thurman said, "in that the system can see if it's headed for the inside of a crater you don't want to land in, or any other hazard. You know it's coming and you're able to avoid it."

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ON THE HORIZON

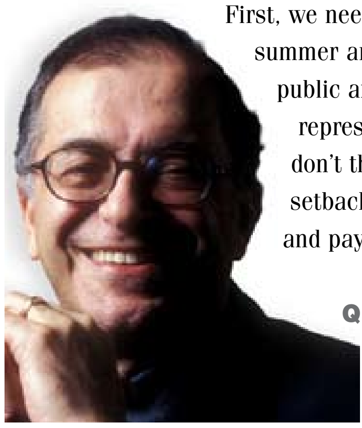
JPL Director Charles Elachi reflects on a recent retreat where Executive Council members discussed the Lab's status, plans and strategies for the near future.

By Mark Whalen

Q: What were the main topics of discussion?

We are in the midst of one of the busiest periods in our history. We have 17 spacecraft flying, with 10 launches between 2007 and 2011—from Dawn, which has just shipped to the Cape, to Juno, which is still in the early definition phase.

Our focus was on what's going to happen after that. What are we doing to keep JPL equally vibrant in the following five years?



First, we need to make sure the Dawn and Phoenix launches this summer are successful, but we also should communicate to the public and to Congress the challenges that these missions represent. There is always a concern to make sure people don't think this is a routine business. Risks are there and setbacks could happen. But also, the scientific opportunities and payoffs are high.

Q: What is the Lab's outlook for future work?

The key discussion we had is how to best position JPL to work as part of the NASA team so that with both assigned missions and ones that are competed, we are in a very strong position.

Remember that one-third of the NASA budget goes to space science. That's $5.5 billion a year, more than three times the JPL annual budget. If we remain competitive, JPL will do well.

How do we strengthen our ability to come up with new ideas? One example is the Purple Pigeons plan, where JPLers are offering innovative mission and instrument concepts. Also, we would like employees to consider career options in the advanced-concept area—coming up with new ideas, refining them, positioning JPL for competing for them—as well as opportunities in research and new technologies.

The key thing is to make sure we have top-notch people in each of those areas.

Q: How is JPL doing in acquiring work through the competitive process?

We discussed the fact that none of our proposals were selected for the recent Scout mission awards. Employees have concern that there's a message there. But JPL had four out of the six finalists in Category 1. Then NASA decided, for programmatic reasons, to focus on aeronomy missions, and we didn't have any. I didn't look at it as anything negative about JPL; in fact, I thought we were very competitive.

But I was delighted that Space Technology 9 was selected. There were five finalists in the competition, including two from JPL, and NASA selected one of the JPL missions. That showed me that we are still a very powerful and imaginative organization in new concepts. But in the world of competition, you should never relax. That's why we put an emphasis on coming up with new ideas.

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Retreat

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For example, in the New Frontiers Program there are some very specific objectives suggested by the academy—including a Venus surface study, lunar sample return, comet sample return and others. The key challenges for our Advanced Studies Office are to understand the strategic goals of NASA and the community; to assure that we have made the appropriate investment so the technology is ready; to see that we have the talent to come up with the implementation; and to give NASA and the review board confidence that we have the right science, the right management, and the right technical approach.

There will also be opportunities for us in astrophysics. NASA has to complete the James Webb Space Telescope and Sofia, and then beyond that there will be discussions about future missions. There are two areas of particular interest to JPL—one is in exoplanets, looking at neighboring solar systems; that's an area of high scientific and public interest. The other area is the understanding of dark energy and dark matter; there may be a number of missions there. The combination of Campus and JPL researchers put us in a very strong position in this area.

Q: Will JPL see more non-NASA work in the next few years?

Even though the space science program is reasonably healthy, we need to expand our technology investment. And considering all the demands on NASA—space science, the crew exploration vehicle and going beyond Earth orbit—it has put stress on the technology budget.

One approach we're taking is to expand our customer base for technology work that is of mutual interest to NASA and other agencies. We have demonstrated technologies that are useful for both the Department of Defense and NASA. There is a lot of common ground—in optics, telescopes, radar, GPS, communications, robotics and more.

Dutch Slager / JPL Photolab

Remember that one-third of the NASA budget goes to space science. That's $5.5 billion a year, more than three times the JPL annual budget. So if we get about 50 percent of the future activities not yet assigned, JPL will do well.

This has been very successful recently. We envision that about 10 percent of JPL's work will be with DoD next year. Beyond that, with the relationship between developing energy sources, global change and how they impact our environment, JPL has a lot of capability to offer in the study and mitigation of global environmental issues of our planet.

The challenge will be to not only develop cleaner, better or more green energy sources, but also how these energy sources affect the environment. With our capability on global monitoring, atmospheric chemistry, our understanding of many energy sources that we use in our spacecraft—solar, batteries and liquid hydrogen—I think we can assist the nation from an end-to-end, system engineering point of view.

There might also be some broader interest in working with other agencies, such as the National Oceanic and Atmospheric Administration, the Department of Energy and the Environmental Protection Agency.

On April 25 we had an all-hands discussion on global change, and I plan on holding other sessions to see if there are ideas that capitalize on our space experience and are complementary with NASA's interests.

Q: How does the Mars Program look right now? What about Earth science and the rest of planetary?

I think we have a very thoughtful Mars program that is a good example of a long-term strategy. Between Mars and the rest of planetary, there's a respectable NASA budget of $1.5 billion to $1.6 billion per year. So the planetary program is reasonably healthy.

Most of the non-Mars activity is competed. Opportunities in the New Frontiers Program come up every three years, and with the Discovery Program it's every year and a half. And there is now discussion at Headquarters about a flagship outer-planets mission. Because of its size, most likely this will be an assigned mission. In a sense, it's a follow-on to the Voyager, Galileo and Cassini missions.

In general, I'd say the planetary program is pretty healthy. There are opportunities for JPL, but we will have to earn it; it won't be just handed to us.

In Earth science, a recent report laid out what the scientific community recommends be done over the next decade, and they suggested a series of missions in three-year blocks. For at least half of those, JPL is strongly positioned to either make the case for an assigned mission or can successfully compete for it.

There are a lot of opportunities in all of those key areas, and we have to work with NASA Headquarters to determine how JPL can best contribute.

Q: How is JPL benefiting from its relationship with the campus?

JPL and the campus have an excellent relationship and we need to keep that strong. We now have joint faculty and research appointments, and strong engagement from Caltech's new president, Jean-Lou Chameau, who is very positive in helping JPL stay at the forefront. I would say our interactions with the campus are probably the best I've seen in the 36 years I've been here.

I also value tremendously the benefit we get from the Caltech Board of Trustees. These are very distinguished, experienced people from the aerospace industry, government and private sector, and their advice helps us stay on the leading edge of excellence.

We are also looking at continuing to strengthen our relationships with other universities, which are key players in defining our strategic approach to implementing future missions.

Q: Is there room for improvement on JPL's interactions with the outside science community?

In general, the outside community looks positively at JPL. But often it's a challenge for scientists or faculty members, accustomed to working within small groups, to communicate with a large organization like JPL. So let's make JPL more science-friendly, so that the outside community sees us as a place that is anxious to help and work with them.

For example, when I talk to the news media, they tell me what a great experience it is to deal with JPL. They always get their questions answered and always are treated in a friendly way. I would like to see that image across all of JPL's interaction with the outside world—that we are a very open, respectful place, despite all the bureaucratic limitations.

Q: Have plans been worked out to staff the new Flight Projects Building?

The building will provide space for 500 to 600 people. We will remove some of the trailers and other lesser-quality space, accounting for 150 to 200 people, so we'll have 300 to 400 newly available spaces. We want to improve the quality of space for staff members already here at the Lab, so people have more elbow room. I would like to see a well-organized effort to co-locate some divisions. I'd also like to better accommodate people doing science and research who need offices next to labs. And we don't want group supervisors sharing an office with one of their employees.

A group representing various divisions has been formed to identify the best ways to manage that space. The new building will become available in approximately fall 2008.

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Space Technology 9

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A sounding rocket test spacecraft and its parachute (right) after touching down in the White Sands Missile Range. The two JPL camera lenses are visible in this end of the spacecraft. JPL's Andrew Johnson (left), who developed the complex algorithms used to recognize terrain features and to locate spacecraft descent images on a digital reference map, surveys the exact touchdown location of the test spacecraft.

Andrew Johnson (left) and Paolo Bellutta in a U.S. Army helicopter just before it lifts off from the recovery site.

Photos courtesy of Sam Thurman

Rather than having a spacecraft rely solely on inertial sensors for guidance, Space Technology 9's computer vision system will provide for images to determine location before deceleration and atmospheric entry and additional imaging updates during terminal descent.

"One of the reasons computer vision as a means for terrain-relative guidance is so appealing is because it can work at so many different places," Thurman noted. "Europa, for example, has bizarre features caused by stresses and strains in its icy crust, leading to sharp ridges and chasms that crisscross all over the surface. Earth's moon and Mars have many relatively large flat spots to send landers but there really aren't any large flat spots on Europa. So it's much harder to eventually go to a place like Europa without having some kind of ability to see terrain, recognize where you want to go—and don't want to go—and get there safely."

Besides the benefit of avoiding hazards, Space Technology 9 looks to provide the most precise landings ever attempted on planetary bodies. "We want to be able to deliver future landers or impactors to within 100 meters (about 328 feet) of a targeted landing site, with 99 percent probability, and in conjunction with that, we want a system that can recognize meter-size landing hazards," Thurman said. "For comparison, the Mars Exploration Rovers were designed to land, with a 99 percent probability, within 35 to 37 kilometers (22 to 23 miles) of where we wanted to be."

The project will test the system with a series of sounding rocket missions at White Sands Missile Range, N.M., chosen due to its geology and variety of terrain types, many of which are similar to surfaces of the moon and Mars. These missions will be conducted in a partnership with the Wallops Flight Facility, which runs the NASA Sounding Rocket Program, and Langley Research Center.

Sounding rockets are small vehicles used mostly to carry science experiments into space for short periods of time and they're typically built around rocket motors from surplus or retired military ordnance. The Space Technology 9 test missions, for example, would last about 15 minutes. By comparison, the Mars Exploration Rovers took about 10 minutes from atmospheric entry to touchdown.

"Sounding rockets are useful because they achieve very high accelerations and speeds comparable to those of a decelerating planetary lander, during both ascent and re-entry," noted Thurman.

A developmental test flight last year at White Sands obtained inertial sensor data over a 122-kilometer-high (75 mile) trajectory and low-altitude imaging data from about 20,000 feet on down, Thurman said. "We didn't have a computer vision system onboard but we used the pictures and sensor data to test the software we'd eventually run in an onboard computer. The test flight we plan for next year will allow us to get images of the ground taken from space for the first time (as well as inertial sensing again), then use that knowledge, along with the results from our first flight, to do a detailed design of the onboard computer system and software."

If all goes well in testing over the next two years, two end-to-end test flights would be scheduled for 2011.

"This would give us redundant opportunities to prove our onboard computer system for real," Thurman said. "We have two of them for the same reason we had two Mars Exploration Rovers. If problems or difficulties are encountered during the first of those two final missions, we'll have another opportunity to incorporate fixes and corrections based on what we've learned."

The results of the first test mission last year also provided an unexpected bonus for the Phoenix Mars lander, scheduled to launch in August.

In evaluating candidate landing sites last fall, the Phoenix Project learned that Larry Matthies, Space Technology 9's computer vision principal investigator, was developing a recognition algorithm for the terrain-relative guidance system, and asked if they could use these algorithms to analyze their high-resolution images from Mars Reconnaissance Orbiter.

Phoenix also benefited from the data obtained from the rocket's inertial sensors during the Space Technology 9 test flight. "Like Phoenix, our terrain-relative guidance system has an inertial measurement unit with gyroscopes and accelerometers used for inertial navigation," Thurman said. "So we're using the test data from the rocket to test the inertial navigation software on Phoenix to make sure it works right."

Thurman lauded JPL's "time-honored approach" where test and validation objectives for new systems are achieved incrementally over multiple tests, enhancing the quality of computer-model validation efforts and minimizing risk. "One of the benefits is you get products and knowledge along the way that you can use for other beneficial purposes you didn't realize ahead of time," he said. "When we started that first flight test, I had no idea we'd be able to use the results to help Phoenix out, but we have.

"But that's what the New Millennium Program is for, to make just that kind of thing happen."

JPL's Calina Seybold is Space Technology 9's concept study team leader. Other key JPL participants include Matthies; Robert Locke, project system engineer; Shawn Goodman, flight system manager; and Shyam Bhaskaran, project technologist.

"We hope that within the next 10 years the first operational use of the terrain-relative guidance system will take place," Thurman said, noting that possibilities could include an asteroid sample return mission as well as the human spaceflight program.

"One of the things I like about this capability is its potential widespread usage—human flights to the moon, space science missions, Mars, Europa, asteroids and comets," Thurman said. "That's been JPL's history—push the boundaries of what's been done and do new things, and that's almost always meant going to places we've never been before."

News Briefs

Don Bickler

Club honors Mars orbiter, Stardust

JPL's Mars Reconnaissance Orbiter and Stardust missions were honored last month with Stellar Awards from the Space Center Rotary Club of Houston.

The Mars Reconnaissance Orbiter development and operations team was honored for the successful development, launch and operations of the orbiter. James Graf, deputy director for JPL's Earth Science and Technology Directorate and former project manager for the orbiter, accepted the award on behalf of the team.

The Stardust flight and recovery team was recognized for its exceptional achievement during the historic seven-year planetary space flight to bring to Earth samples of primordial material from a cometary nucleus. Accepting the award on behalf of the team was Tom Duxbury, Stardust project manager.

Board releases Global Surveyor findings

After studying Mars four times as long as originally planned, JPL's Mars Global Surveyor orbiter appears to have succumbed to battery failure caused by a complex sequence of events involving the onboard computer memory and ground commands.

The causes were released April 13 in a preliminary report by an internal review board, which took an in-depth to look into why Global Surveyor went silent in November 2006 and recommend any processes or procedures that could increase safety for other spacecraft.

"The loss of the spacecraft was the result of a series of events linked to a computer error made five months before the likely battery failure," said board chair Dolly Perkins, deputy director-technical of Goddard Space Flight Center.

"It is important that all of us at JPL take note of the lessons learned from Mars Global Surveyor and apply them to all of our work," said JPL Director Charles Elachi.

Mars Global Surveyor, launched in 1996, operated longer at Mars than any other spacecraft in history.

For more information on the report, visit *www.nasa.gov/mission_pages/mgs.*

Bickler earns engineering honor

Don Bickler, principal engineer in the Mechanical Engineering Section [352], has been named a fellow of the American Society Of Mechanical Engineers.

With JPL since 1975, Bickler was honored for his career in mechanical engineering, spanning more than 50 years. Among his accomplishments, he is credited with the designs of a propane carburetor, a light source simulating sunlight and the suspension system used for vehicles sent to Mars. In his later years Bickler has focused on training and mentoring young engineers. The organization noted his earning the NASA Exceptional Engineering Achievement Medal for the development of the mobility design of the Mars Pathfinder Sojourner rover.

Fellow is the highest elected grade of membership within the society, with only 2.5 percent of its membership earning the designation.

Retreat

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Q: What other institutional issues are being worked now?

To make sure we are the most effective and efficient organization, we need to stay in the forefront on technology as well as in our administrative and business activities. We need to make sure the people we have onboard now have the opportunity for training and mentoring, and help to train the next generation of JPLers.

There is concern about too many internal reviews, and we need to decide how to streamline this and many other non-technical things that are the responsibility of group supervisors and section managers. We're going to continue to implement requirements such as safety, security, rebadging, ITAR and so on, but we want to relieve them from some of that additional burden.

We also want to invest in our technology and our infrastructure. The intent is to keep our investment to at least the same level we had last year, and maybe increase it in the future, depending on our business base. We also thought about how to streamline the process and show a direct connection between the investment and the future objectives.

We have decided to increase the fiscal 2007 budget for our technical infrastructure—including hardware, software and facilities—by $8 million, plus a "placeholder" for an additional $5 million in 2008.

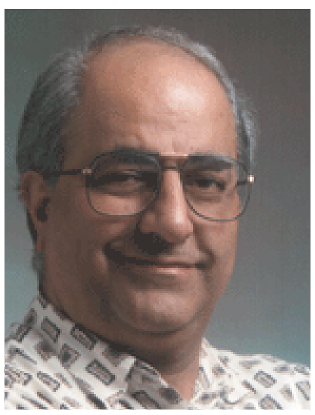
We are going to continue to tailor our earned value management system to best work with the flight projects. We will also assess the activities of the JPL management councils, which have been in place for five years now. It's a good idea, every five years or so, to look at how you are managing and look for ways to improve.

Another major area of discussion was JPL's core competencies. How do we continuously strengthen the key capability we have here to enable us to do our job?

Q: Overall, what is your outlook for the near term?

I am very optimistic. I am absolutely confident that JPL five years from now—and 10 years from now—will be as busy, vibrant and as exciting as today. The NASA budget includes a reasonably healthy space-science budget. Our challenge is to make sure we earn our share, with either assigned missions or competed missions. I have no doubt that we have the talent to do that, and the Executive Council's focus will be how we provide the environment, investment and opportunity to make sure we are successful.

Passings



Homayoun Seraji, 59, supervisor of the Advanced Robotic Controls Group, died April 16.

An internationally known robotics expert, Seraji finished high school as the top-ranked student in his native Iran. He joined JPL in 1985 after a 10-year tenure at that country's University of Sharif. He published more than 200 papers in peer-reviewed journals and refereed conferences, and held 10 patents. In 2003 he was named the most-published author in the history of the Journal of Robotic Systems.

Seraji is survived by his wife, Dinoush, daughter Mona and son Reza. Memorial services were held April 22.

Ernest Nordquist, 87, a retired engineering associate in Section 322, died March 30. He worked at JPL from 1950 to 1985.

Richard Decker, 93, retired from Section 344, died April 1. He worked at JPL from 1968 to 1978.

Socorro Shiraishi of Section 215 died April 5. She was 70.

Shiraishi had worked at JPL since 1980 and was on long-term disability. She is survived by her husband, Richard, and son Richard Jr.

Letters

On behalf of the Devirian family I would like to express our deep appreciation for the many kind comments, cards and donations to charity that we have received on the passing of my mother. With my Dad's 30 years at JPL, my 40 and my wife's 20, she considered herself to be a part of the JPL family and would be very pleased at the response.

Michael Devirian

My family and I wish to thank our friends and co-workers at JPL for their thoughts, prayers, kind words and condolences at the recent illness and passing of my mother. The flowers from JPL are lovely, and the gift basket sent by Section 346 was deeply appreciated. Thank you.

Bill Nesmith

Thank you so much for the beautiful plant and basket given in remembrance of my father, Richard O'Connell. It was a pleasant surprise and much appreciated. The support and understanding of my co-workers at JPL means a lot.

Michael O'Connell

My family and I very much appreciate the cards, donations and plant sent to us following the passing of my dad. Your expressions of sympathy have been very helpful during a difficult time.

Steve Durden

Retirees

The following JPL employees retired in May:

James Weiss, 35 years, Section 320; **John Pensinger**, 21 years; **John Wellman,** 21 years, Section 720.

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