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Gearing up for the next great rover

Mars Science Laboratory begins assembly, test and launch operations

By Mark Whalen

It's only about a year and a half until the biggest and most sophisticated Mars rover ever built, the Mars Science Laboratory, is scheduled to take off from Kennedy Space Center. Twice as long and five times as heavy as the Mars Exploration Rovers Spirit and Opportunity, the Mars Science Laboratory will examine rocks and soils in greater detail than ever before to determine environmental conditions that could have supported microbial life now or in the past. The mission will also examine the martian atmosphere and determine the distribution and circulation of water and carbon dioxide.

The project recently passed one of its biggest milestones when the assembly, test and launch operations phase began. Project Manager Richard Cook provides an update.

Q: WHAT HAPPENS DURING THIS NEW PHASE? HOW LONG DO THESE ACTIVITIES GO ON?

A: Assembly, test and launch operations will go all the way through launch. We will spend the next six or seven months or so putting the spacecraft together up until its full configuration, followed by a series of environmental tests—including acoustic and thermal vacuum—in the launch and cruise configurations.

Basically we're starting up the process of putting the spacecraft together. Right now we're doing the electronics integration. The mechanical pieces don't get delivered until this summer, so we'll use these first few months to get the electronic parts to work together.

The instruments will get delivered between June and October. We don't need them for the first set of environmental tests, so it's not until we get the rover configuration that all the instruments are integrated, which will be in January or February 2009. Of course, all instruments will have been tested by their principal investigators, but we'll do integrated testing with them in the fall before putting them on the rover.

Another set of environmental tests to simulate what it will be like for the rover to be on the surface of Mars will be done in spring 2009.

In May 2009 the whole spacecraft—the rover, along with the descent and cruise stages—all get shipped to Kennedy Space Center; from that point on it's the quick launch operations phase where, effectively, we put it all back together, very carefully put the flight batteries in, close out all inspections, make sure it's ready to go.

The vehicle will then get fueled in August and will be sent out to the launch pad; the radioisotope thermoelectric generator power supply will be integrated just a few days before launch.

ABOUT SIX MONTHS AGO YOU DECIDED TO CHANGE TO AN ALTERNATE MATERIAL FOR THE SPACECRAFT'S HEAT SHIELD. WHY WAS THAT CALL MADE? HOW IS THE NEW HEAT SHIELD PROGRESSING, AND WILL IT BE READY IN TIME?

Our testing on the original heat shield showed that it might have trouble protecting the lander upon entry into Mars' atmosphere. Since then we've been on a path to get the new heat shield built.

The heat shield had a design review in early February and will have a final design review in June. The manufacture of the tiles that make up the heat shield material is underway and it will be put together this fall.

The plan is behind where we wanted it to be, but we don't actually need the heat shield until we go to Florida in June 2009. We are on track to make that date.

THE PROJECT HAS HAD SOME FUNDING ISSUES. WHAT'S THE LATEST?

Certainly the heat shield issue contributes to the project's need for additional funding.

But some of the hardware has taken us a lot longer to produce, and because of that, the workforce to produce it has had to stay on much longer than we had originally thought. The same is true for some of our vendors, some of whom still have a lot of hardware to deliver.

DO YOU HAVE ENOUGH PEOPLE TO GET THE JOB DONE?

We're at about 700 full-time equivalent JPL staff, as well as some part-timers. But as far back as last fall we thought at this point we'd be down to about 400. To finish the delivery of all this hardware and to get to a 2009 launch we really need to stay at 700 for the next couple of months.

The complexity of this project is substantially more than the Mars Exploration Rovers, so even though the schedule is longer from the beginning of the project, it still requires a much greater effort at this phase of the project than we thought at the beginning.

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Mobility engineer Sean Haggart tests a Mars Science Laboratory wheel.

Mars Science Laboratory *Continued from page 1*

We've also had some notable problems during the development, somewhat outside the normal range of problems you might expect to have. Usually you'd have one or two significant problems but so far we've had four or five—the heat shield, the actuators, the sample processing equipment, the motor controller and one of the key instruments.

WITH ALL THAT SAID, ARE YOU CONFIDENT OF MAKING YOUR LAUNCH DATE OF FALL 2009?

Yes. Implementing this project is really like fighting a war on many fronts. And the only way you can do that is to have enough talented people and resources to dedicate to each front.

That's where JPL is fortunate, in the sense that we have a great cadre of people who can focus on any problem that comes up. And although we're certainly straining the Laboratory's ability to solve all these problems at the same time, my feeling is that we've got good people in all the problem areas, and they're making progress. It's always possible that we could have a major problem we can't get out of, but at this point we have the proverbial rider for every horse, so that gives me confidence we can make it. Of course, it's predicated on us having the financial resources to do that, and that's why we're asking for an augmentation.

NASA has been very clear with us about the importance of this project. Everyone's highest priority is to have a successful mission. There have been questions about whether we will be ready in 2009, but I believe we will be ready with a quality product. If we aren't, I'll certainly be the first to tell everyone that we shouldn't launch. In the meantime, however, NASA has made it clear that they will provide the funds required to get to 2009 without cutting any corners. They have instructed us to go as hard and as fast as we can and the money situation will get resolved. So that's what we're doing.

HOW HAVE THE PATHFINDER AND THE MARS EXPLORATION ROVERS EXPERIENCES MOST HELPED YOU AND THE MISSION TEAM?

It's really what we've tried in the past that enables us to do what we're doing now—building on the past successes, with an eye on the past problems as well—to learn how to take that next step.

Each mission is a significant step forward but to a certain extent we take for granted that we've done similar things before, then we find that the challenges are as big as last time, if not bigger.

Some time ago I thought about the celebrations that ensue when we have a successful landing; there's a reason people react that way when it lands, right? *[Laughing]* I mean, it's been a lot of work each time.

But that's what JPL is about—to not do the same thing again—so you'd think this would be getting easier, and it's not. It's as difficult, if not more so, every time. And it's only because of what we've done in the past that makes it possible. If they asked us to do Mars Science Laboratory without having done the Mars Exploration Rovers or Pathfinder … there would be no way.

IT'S BEEN ONLY 11 YEARS SINCE JPL LANDED PATHFINDER ON MARS, BUT IN THAT TIME WE'VE GONE FROM A MICROWAVE OVEN–SIZED SOJOURNER ROVER TO THE MUCH BIGGER SPIRIT AND OPPORTUNITY ROVERS STILL ON MARS, AND NOW MARS SCIENCE LABORATORY, 10 TIMES AS MASSIVE AS THE PREVIOUS GENERATION. COMPARED TO MARS SCIENCE LABORATORY, DO YOU FEEL THAT PATHFINDER WAS MORE ABOUT MASTERING THE TRIP TO MARS THAN ABOUT DELIVERING A BIG ROVER?

That's interesting; that's one example of when I said each mission is more challenging as the time before. If it were just the payload that were the new thing, I think Mars Science Laboratory would still be more complex than our previous rovers. But with Mars Science Laboratory we're also changing the whole entry, descent and landing approach; it's a brand new way of landing that builds on what we've learned in the past. It doesn't use airbags, as we used on Pathfinder and the Mars Exploration Rovers, but it has its own set of challenges.

Dutch Slager / JPL Photolab

The "Scarecrow" model, right, which shows Mars Science Laboratory without its instruments, dwarfs the Mars Exploration Rover, left, and Pathfinder's Sojourner.

Dutch Slager / JPL Photolab

Measurements of the completed descent stage structure are taken in Building 150 in early March. From left: Ray Rayas, Brett Harmon, Ben Thoma, Juan Pacheco.

Another example on Mars Science Laboratory is the sample acquisition and processing equipment, which to a certain extent is a new function—both Phoenix and the Mars Exploration Rovers have an arm, but the complexity of the sample processing those missions have flown, compared to what we're doing, is a big step up for Mars Science Laboratory.

In almost every dimension, Mars Science Laboratory is about pushing our capabilities—the landing system, the rover, the power generation, sample processing and instrumentation all represent extensions of what's been done in the past; in some cases, substantial extensions. You can choose two or three of those things and make them much better and it will be a difficult mission; if you choose all of them and make them better it becomes very challenging, something that is really pushing what we can do.

WHAT'S NEXT IN THE PROGRESSION TO LAUNCH?

The pieces are beginning to come together; by late summer we should have something that looks like a rover, as well as the other major components of the vehicle, in the Spacecraft Assembly Facility. By October or November we will have something that basically looks like a spacecraft ready for launch and then we'll start to do environmental testing.

In the meantime, there will be a lot of work going on in the testbed, including proving out the flight software and the functionality of the vehicle. The mission operations area is beginning to staff up to handle the operations planning.

People ought to visit the viewing gallery in Building 179 and see what's going on. It's starting slowly but around June we'll be running two shifts of operations five days a week. I think it'll be a beehive of activity all the way to launch, so people should come down and take a look; it will be gripping to see.

JPLers to contribute to moon orbiter

Spacecraft nuclear power, terrestrial ecology studies also awarded

Two JPL scientists are among 24 selected by NASA to initiate new investigations and assist with planned measurements to be conducted by the agency's Lunar Reconnaissance Orbiter.

Scheduled to launch Oct. 31, the orbiter will conduct a one-year primary mission exploring the moon, taking measurements to identify future robotic and human landing sites. It will also study lunar resources and how the moon's environment will affect humans.

Tom Duxbury, manager of the Epoxi and Next projects and a scientist on Odyssey, Mars Reconnaissance Orbiter and Mars Express, and Amanda Hendrix, a member of Cassini's ultraviolet imaging spectrograph team, have been named participating scientists for Lunar Reconnaissance Orbiter.

Duxbury's study, "Lunar Local and Global Cartography and Calibration," will contribute to the production of the first highly accurate 3-D lunar cartographic maps; the registration and cross correlation of different payload instrument data to the precision 3-D cartographic maps to map mineralogy across the whole moon; and the characterization and assessment of future robotic and human landing sites.

The study proposes to use data from several Lunar Reconnaissance Orbiter instruments. The Lunar Radiometer Experiment will map the temperature of the lunar surface at 300-meter horizontal scales; the Lunar Orbiter Laser Altimeter will provide a precise global lunar topographic model and geodetic grid, enabling precise targeting, safe landing and surface mobility, and will characterize the polar illumination environment by imaging the moon's permanently shadowed polar regions; data from the orbiter's camera will be used to acquire images to assess less than 1-meter scale features to facilitate safety analysis for potential lunar landing sites; and the Mini Radio-Frequency Technology Demonstration, which uses synthetic aperture radar imaging modes.

Hendrix's "Investigation into Lunar Surface Composition and Weathering Effects" will utilize the Lyman-Alpha Mapping Project instrument in the far ultraviolet to map out the lunar surface during the science phase of the mission to study composition and understand space weathering effects on different terrains of differing mineralogies. The instrument will also use Lyman-alpha "skyglow" to illuminate permanently shadowed regions of the poles to search for water ice. This is the first demonstration of the same technology used by military night vision that can be applied to space exploration.

Hendrix said items of interest on the moon, such as ilmenite—an oxide mineral of titanium and iron—are spectrally distinctive in the far ultraviolet. In probing and mapping the composition of the lunar surface, she said, it is vital to understand the effects of weathering in order to determine the true nature of the lunar surface.

The Lunar Reconnaissance Orbiter mission also will involve a spacecraft called the Lunar Crater Observation and Sensing Satellite, which will impact the lunar south pole to search for evidence of polar water frost.

Tom Duxbury and Amanda Hendrix will be participating scientists on Lunar Reconnaissance Orbiter, set for launch this fall.

The orbiter and the sensing satellite will launch together aboard an Atlas V rocket. The orbiter's trip to the moon will take approximately four days, while the Lunar Crater Observation and Sensing Satellite will take several months to reach the moon.

The Lunar Reconnaissance Orbiter spacecraft is being built and tested at Goddard Space Flight Center. Ames Research Center manages the Lunar Crater Observation and Sensing Satellite.

NASA received 55 proposals in response to a NASA research announcement for Lunar Reconnaissance Orbiter. Selection criteria included intrinsic merit, relevance, responsiveness to planetary science goals and objectives, as well as cost.

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Two studies led by JPL have been awarded under NASA's Discovery and Scout Mission Capabilities Expansion, a new program element that solicits mission concept proposals for small planetary missions that require a nuclear power source, such as the Advanced Stirling Radioisotope Generator currently under development by NASA.

Kevin Baines of the Asteroids, Comets and Satellites Group will lead a study to implement a small Stirling-cycle nuclear source to power the JPL-proposed Venus Aerostatic-Lift Observatories for in-situ Research balloon mission to explore the atmosphere of Venus.

The proposed mission would have up to two helium-filled balloons, one at a tropical latitude, the other at a polar latitude. Each balloon would fly about 56 kilometers (about 35 miles) above Venus' oven-hot surface. Flying in the powerful wind streams of Venus for several weeks, the balloons would circumnavigate the globe several times, learning about the planet's dynamic circulation, meteorology and chemistry, as well as seeking isotopic clues to the origin and evolution of Earth's sister planet. "The nuclear option we're now studying will allow Valor to make observations continuously as it flies around the planet," Baines said. "It also will allow an effective option for powering the balloons near the poles where sunlight is poor."

Baines said the study will deal with problems associated with dissipating the heat from a nuclear source while inside the entry vehicle during entry and en route to Venus. It will also look at how to implement this power for the balloon's gondola and perhaps to help augment buoyancy via heating the buoyant gases inside the balloon envelope.

The study's co-investigator is JPL's Tibor Balint.

Michael Hecht of the Instrument Systems Implementation and Concepts Group will lead a study for an Advanced Stirling Engine Radioisotope Generator–powered thermal drill that would allow scientists to explore the polar cap of Mars, much as ice cores on Earth are studied to learn about past climate.

Hecht noted that the thermal drill is a descendant of the JPL cryobot, which moves through ice by melting the surface directly in front of it.

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From left: Kevin Baines and Michael Hecht will lead studies on nuclear power; Marc Simard and Robert Treuhaft will address terrestrial ecology.

News Briefs

Lew Allen Awards bestowed

Paul Johnson and Jason Rhodes, both of Division 32, have received the 2007 Lew Allen Award for Excellence.

The annual awards recognize and encourage significant individual accomplishments or leadership in scientific research or technological innovation by JPL employees during the early years of their professional careers.

Johnson was recognized for research in the areas of atomic and molecular physics, physics and chemistry of planetary ices, and instrument development. Rhodes was honored for outstanding scientific leadership in the field of weak lensing, which enabled the first large-scale measurement of the three-dimensional distribution of dark matter in the universe.

Each winner receives a wall plaque and a research award of $25,000 from the Research and Technology Development Fund, which is used at JPL to enhance the professional efforts of the awardees.

From left: JPL Director Charles Elachi, Paul Johnson, Jason Rhodes, Chief Scientist Daniel McCleese.

The award was established in 1990 in honor of Dr. Lew Allen, who served as JPL's director from 1982–90.

Kids' day April 24

Registration is underway for JPL's Take Our Children to Work Day, scheduled for Thursday, April 24.

Patterned after the Ms. Foundation's National "Take Our Daughters and Sons to Work Day," this event is designed to help expand your child's awareness of his or her potential, and the many future options available in exploring space. All children between the ages of 9 and 17 are welcome.

Register online at *http://hr.jpl.nasa.gov/toworkday.* Print the authorization/release form, which is system-generated after completing the registration process. Then obtain appropriate signatures on the form, which requires supervisor and parent/guardian approval.

Return the completed form to T1720-D, attention Nancy Kapell. Deadline for registration and submission of the authorization/release form is Thursday, April 10.

For more information, please visit *http://hr.jpl.nasa.gov/toworkday* or call Kapell, ext. 4-9432.

Studies

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Co-investigators on the study are JPL's Miles Smith, Sarah Milkovich and Andy Spry, along with Caltech Professor Oded Aharonson.

Mission design assistance for these mission concepts will be offered by NASA during the six-month studies.

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JPL was also selected to lead two studies under NASA's Research Opportunities in Space and Earth Sciences Program in the terrestrial ecology area.

Marc Simard of the Suborbital Radar Science and Engineering Group is the principal investigator for "3-D Vegetation Structure Using L-Band Synthetic Aperture Radar Interferometry and Lidar."

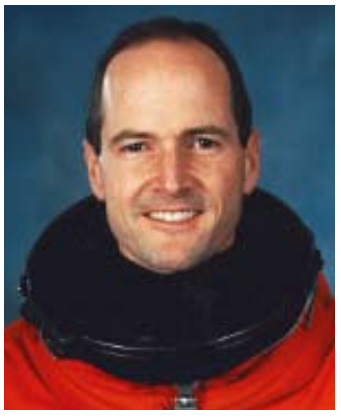
The proposal addresses issues related to the application of the Deformation, Ecosystem Structure and Dynamics of Ice mission to characterize 3-D vegetation structure; the mission combines the ability of lidar to measure localized canopy height profiles and of radar to provide wide area estimates of canopy height. The overall objective of the proposal is to study the most likely scenarios for the mission and quantify their performance and the remaining uncertainty in the retrieval of vegetation structure parameters such as height, density, biomass and canopy/biomass dynamics.

Robert Treuhaft of the Global Positioning Satellite Systems Group is the principal investigator for "The Performance Of Structure and Biomass Estimation From Interferometric Synthetic Aperture Radar 3-D Vegetation Missions At L-Band Over Tropical Forests."

This proposal bridges the gap between the performance of published interferometric synthetic aperture radar tests and that of a repeat-track, L-band mission. Structure- and biomass-estimate performance will be evaluated as a function of realistic operation and analysis modes by assessing the limiting or best possible accuracy of structure and biomass estimation over a variety of complex tropical forests, and assessing the scenario-dependent accuracy for smaller numbers of baselines that may characterize the Deformation, Ecosystem Structure and Dynamics of Ice mission.

NASA said 59 proposals were received for this solicitation, and 10 have been selected for funding at this time. The total funding to be provided for these investigations is approximately $7 million over three years.

Passings



G. David Low

G. David Low, 52, a former astronaut and former JPL employee, died March 15.

Low worked in JPL's Spacecraft Systems Engineering Section from 1980 to 1984. During that time he was involved in the preliminary planning of several planetary missions, an autonomous spacecraft maintenance study, and the systems engineering design of the Galileo spacecraft. Following a one-year leave to pursue graduate studies, Low returned to JPL where he was the principal spacecraft systems engineer for the Mars Geoscience/Climatology Observer Project.

Low became an astronaut in 1985. A veteran of three space flights, he logged more than 700 hours in space.

In 1996, Low joined Orbital Sciences Corporation's Launch Systems Group in Dulles, Va., where he worked until his death.

He is survived by his wife, JoAnn, their three children, his mother, Mary, and his brothers and sisters.

Fred Ross, 76, a retired senior Photolab assistant, died March 6.

Ross joined JPL in 1967 and retired in 1994. He is survived by his wife, Barbara, and four children. Services were held at Woods-Valentine Mortuary in Pasadena.

John Gatewood, 75, a retired senior engineering associate, died March 18.

Gatewood worked at JPL from 1957 to 1994. Twelve of those years were spent developing hardware for low-temperature physics experiments in low-gravity environments.

He is survived by his wife, Janice; sons Tom and Guy; daughter Georgia; and grandchildren Kiernan, Fiona and Liam.

Services were scheduled April 5 at Descanso Gardens in La Cañada.

Letters

My deepest thanks to JPL colleagues and friends for their support and expressions of sympathy following the sudden passing of my fiance, Ralph B. White. Ralph always enjoyed his interactions with JPL people, even with those on our Safety Committee, who he had to persuade to allow our scientists to dive in deep-sea submersibles. His spirit of exploration and adventure will continue to live on in many of us.

Rosaly Lopes

I would like to express my sincere thanks and appreciation to my friends and coworkers at JPL for the many expressions of sympathy at the passing of my mother, Jane Overholt. The cards, flowers and kind words of support were greatly appreciated during this difficult time. Thanks also to JPL for the beautiful plant my family received. Sincerely,

Jann Overholt

To all my friends and colleagues at JPL, I would like to express my deepest thanks for their support and prayers on the passing of my mother. Of all the people who inspired me while growing up, she is probably most responsible for giving me the freedom and space to follow my dreams. My thanks to JPL for the lovely Peace Lilly plant and card that helped us through this time of bereavement.

Dwight Holmes

Thank you to my friends in Division 35 and the rest of the Lab for their kind words and condolences over the passing of my grandfather, Ed Sharp. He was a lifelong pilot, veteran, cattle rancher and aerospace enthusiast who took pride in his family connection to our Mars rovers and the Space Station. Many thanks also to JPL for the beautiful plant we received.

Mark Johnson

Retirees

The following JPL employees retired in April:

Fred McLaughlin, 48 years, Section 9120; **Carolyn Stevens,** 40 years, Section 250; **Alice Smilgis,** 38 years, Section 2231; **Joan Pojman,** 30 years, Section 343M; **Mary Johnson,** 24 years, Section 2661; **Charlene Wolf,** 21 years, Section 2032; **Patricia Ehlers,** 19 years, Section 2745.

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