The PLANETARY REPORT

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Beyond The Moon

From The Editor

The Internet has transformed the way science is done—even in the realm of "rocket science"—and now anyone can make a real contribution, as long as you have the will to give your best.

In this issue, you'll read about a group of amateurs who are helping professional researchers explore Mars online, encouraged by Mars Exploration Rovers Project Scientist Steve Squyres and Planetary Society President Jim Bell (who is also head of the rovers' Pancam team.)

This new Internet-enabled fun is not the first, nor will it be the only, way people can participate in planetary exploration. The Planetary Society has been encouraging our members to contribute their minds and energy to science since 1984, when the Pallas Project helped to determine the shape of a main-belt asteroid.

In 1999, your founding sponsorship of SETI@home helped launch the field of distributed computing; its descendants now enlist people around the world searching for a cure for cancer, modeling climate change, tracking earthquakes, and engaging in other scientific projects.

And let's not overlook your contribution to the new Roadmap for Space Exploration that The Planetary Society has already presented in Washington, D.C. to the presidential transition team, the U.S. Congress, and the National Research Council. Through the town halls we held in the United States and the United Kingdom, your support of our advocacy campaign with your letters to Congress, your signatures on petitions, and your donations to the cause, you are helping to determine humanity's future in the cosmos.

There is so much we have accomplished together—and so much more to do before we see human footprints on Mars or peer beneath the ice of Europa. Let's get to work!

—*Charlene M. Anderson*

On the Cover:

The United States has the opportunity to unify and inspire the world's spacefaring nations to create a future brightened by new goals, such as the human exploration of Mars and near-Earth asteroids. Inset: American astronaut Peggy A. Whitson and Russian cosmonaut Yuri I. Malenchenko try out training versions of Russian Orlan spacesuits. Background: The High Resolution Camera on Mars Express took this snapshot of Candor Chasma, a valley in the northern part of Valles Marineris, on July 6, 2006. Images: Gagarin Cosmonaut Training Center. Background: ESA

Background:

A dust storm blurs the sky above a volcanic caldera in this image taken by the Mars Color Imager on *Mars Reconnaissance Orbiter* (*MRO*). Such storms can lift dust particles high into the atmosphere, causing them to seed water-ice cloud formation. Water ice condenses onto the dust particles to form wispy white clouds. Image: NASA/JPL/MSSS

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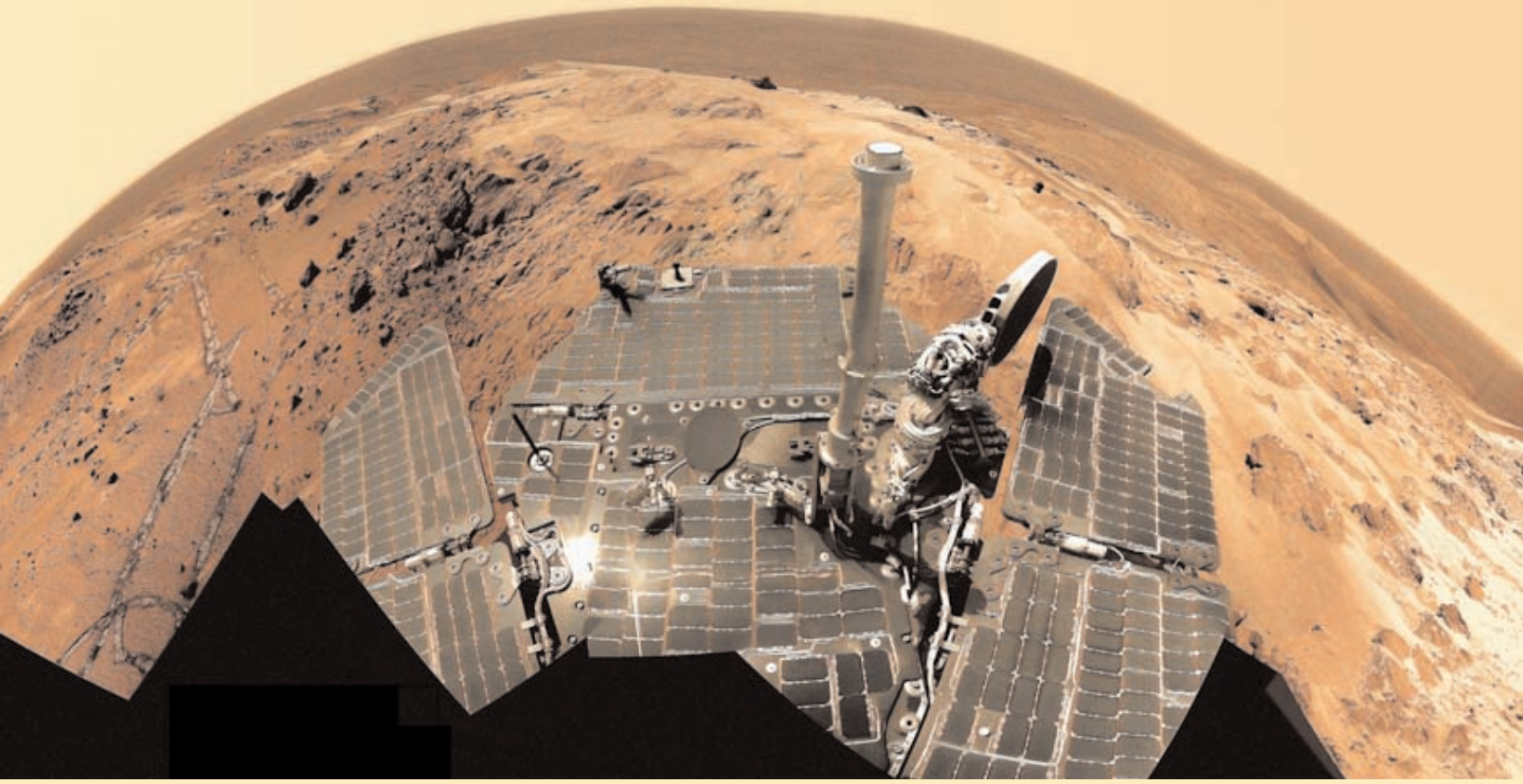
Amateurs Participating in Space Missions



by Doug Ellison

This mosaic, titled Rocky Martian High, *is constructed from images* Spirit *took near the summit of Mars' Husband Hill. The original panorama was promptly noticed by the press, but few people noticed that it accidentally showed both front and back portions of the rover. This corrected version has been widely seen in print and online.*
Mosaic: NASA/JPL/Cornell University/Marco Di Lorenzo et al. Courtesy of Aviation Week and Space Technology

It's not often you get a chance to play with a spacecraft in space. But with missions like the Mars Explorations Rovers (MERs) *Spirit* and *Opportunity*, *Phoenix*, *New Horizons*, and *Mars Express*, the members of the public are—as much as can be—given such an opportunity.

The data from spacecraft that conduct systematic monitoring of Earth and space, such as weather satellites and the *SOHO* solar observing satellite, have been appearing on the Internet in short order for the better part of a decade. The first exploratory mission to share all raw images in near-real time was the twin MERs, which landed in January 2004.

The idea of sharing the images from the 10 different cameras on board each rover with the public via the Web, from the moment the rovers were on the ground, came independently to Principal Investigator Steve Squyres and to Jim Bell, the Payload Element lead for the Panoramic Camera (Pancam) and now Planetary Society president. The decision to put that idea into action cer-

tainly changed my life and has positively influenced many others. With those uncalibrated, compressed images, amateurs like me were able to reconstruct the mosaics and color images the rovers were sending back and to see Mars as quickly as were the scientists and engineers driving the rovers. To share my early, primitive efforts, I started a forum to discuss techniques and results. That forum has since evolved into *Unmannedspaceflight.com*, known to many just as UMSF.

So what do people do with images from *Spirit* and *Opportunity*?

Getting Noticed

Using cheap, free, or even home-brewed image-stitching software, people can take the individual frames and convert them into stitched color panoramas extending to tens of megapixels in resolution. Because of the sheer number of people looking at the images—and the amount of Photoshop® "talent" out there on the Web—it is not uncommon, after a typical rover drive, for new panoramas from the rover to be stitched together and posted to the forum within six hours of the images making it back to Earth. (This state of affairs is quite different from the days when we would wait for new images to be published in science magazines and journals perhaps months after they were taken.)

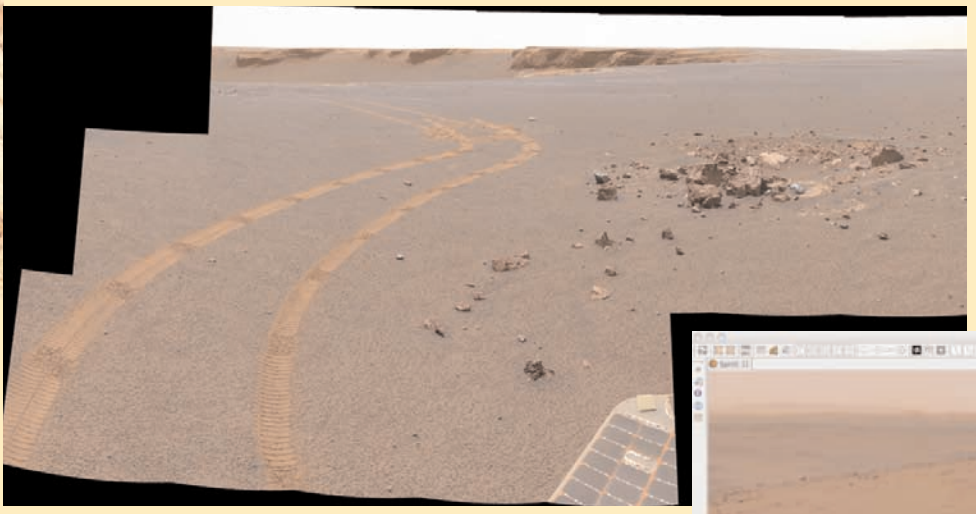
One especially well known creation was spotted by former *Aviation Week* journalist Craig Covault. He saw a visually interesting panorama of *Spirit* images of the area near the absolute summit of Husband Hill. What many don't know is that the images were, in fact, a mistake: two frames that fit beautifully at the bottom of the mosaic showing the back of the rover in context actually should have been taken of the front of the rover, showing the potential work volume of its robotic arm (see image on page 4). But what a beautiful mistake it was!

At the behest of Covault, a team led by Ken Kremer and that included Bernhard Braun, Marco di Lorenzo, and I produced a stitched, tweaked, polished, and then colorized panorama that made the cover of *Aviation Week* under the headline "Rocky Martian High." As if that was not enough, the picture later was featured on the popular "Astronomy Picture of the Day" website, became one of *New Scientist*'s Images of the Year for 2005, and was even seen in the science supplement of a Belgian newspaper.

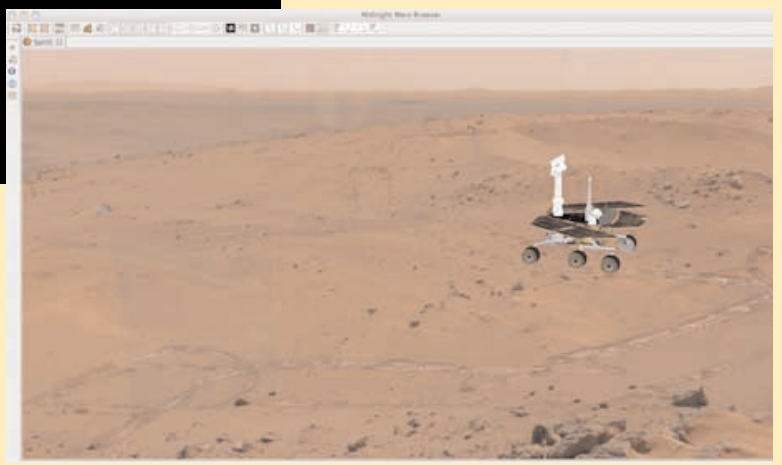
Amateur Experts on Mars

Dan Crotty has made it his job to produce a calibrated color version of every Pancam sequence from the twin rovers. He has created highly stretched movies that show the dust devils screaming past the Columbia Hills and the evolution of their tracks on the northern slopes of Husband Hill.

Creating color images is something of a dark art that inevitably involves an element of interpretation. Crotty's own "true-color" Pancam images are of a slightly more muted Mars than typical color images would suggest. However, it's quite likely that humans on the surface would adapt somewhat to the color cast of the Martian terrain to see something more like Crotty's images.

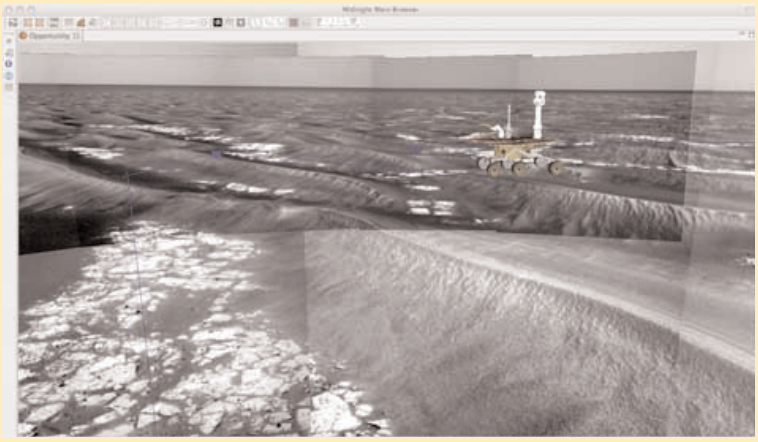


Left: Dan Crotty created this color-calibrated mosaic of* Opportunity *images taken on sol 1162. His "true-color" images of Mars are a bit more muted than other color photos, but this is how the scene might actually look to humans on the surface.
Mosaic: NASA/JPL/Cornell University/Daniel Crotty



Right: Mike Howard created a simple tool that automatically downloaded new images from the rovers. It has since evolved into a much more sophisticated interactive tool that can even reproject the imagery into virtual 3-D space, allowing Pancam and Navcam images to be seen in context, site by site, sol by sol. Here* Midnight Browser *shows* Spirit *driving across the summit of Husband Hill.
Mosaic: NASA/JPL/Cornell University/Daniel Crotty and Michael Howard

This colorized Navcam mosaic shows the clouds and dunes at Meridiani Planum. Mosaic: NASA/JPL/Cornell University/Michael Howard, Tayfun Öner, D. Bouic, and Marco Di Lorenzo



The author created a low-resolution virtual 3-D model of the rovers, which Howard then puts into the images that ultimately become movies of the rover driving from one site to the next. Steve Squyres and other rover team members have come to rely on the fast and accurate work of these amateurs to "see" how the rovers' latest travels went. "It's like they are downloading what's in our heads," Squyres said. Here Opportunity *drives through the dunes of Meridiani Planum.* Mosaic: NASA/JPL/Cornell University/Daniel Crotty and Michael Howard

Crotty's photos stitch together perfectly to make beautiful panoramas, and they feed into the brilliant "Midnight Mars Browser" created by Mike Howard. Howard began by making a simple tool that automatically fetched new imagery from the rovers. It has since evolved into an interactive tool that will download and sort the images, produce color composites and stereo anaglyphs, and even reproject the imagery into virtual 3-D space so that Pancam and Navcam imagery can be seen in context, site by site, sol by sol.

For the ultimate MER experience, I created a low-resolution virtual 3-D model of the MER rovers that Howard puts into the images, so that from the perspective of the rover on one sol, you can watch it drive to the next site. This whole combination comes together as beautiful movies showing such events as *Spirit* driving across the summit ridge of Husband Hill or *Opportunity* riding the rim of Victoria crater. The ability of the virtual rover to follow the tracks made by the real rover is uncanny. I was fortunate enough to show some movies to Steve Squyres. "It's like they are downloading what's in our heads," he said.

To keep track of where the rovers have traveled, the forum has a mapping guru, Eduardo Tesheiner. As quickly as a new panorama appears, Tesheiner puts another virtual pin into a map showing the route the rovers take across Gusev crater or Meridiani Planum.

I can think of no finer testament to the quality and rapidity of the work these amateurs do than words from Steve Squyres himself. "Frequently I'll get up in the

Dan Crotty's and Gordan Ugarkovic's early posts to the Unmanned Spaceflight (UMSF) forum may have been the first time the public saw traces of the ice first inferred by* Mars Odyssey*. Here Dan has made a more accurate, compression-free version based on the calibrated image data released by the* Phoenix *team. *Image: NASA/JPL/Texas A&M University/Arizona State University/Daniel Crotty*

morning," he said, "and the first place I go online is *unmannedspaceflight*, because I know I'm going to get mosaics rather than just raw images [that I would get] if I go through all the firewalls to JPL, because nobody in Pasadena has even woken up yet—I did it this morning to see how our drive went."

Phoenix Gets into the Action

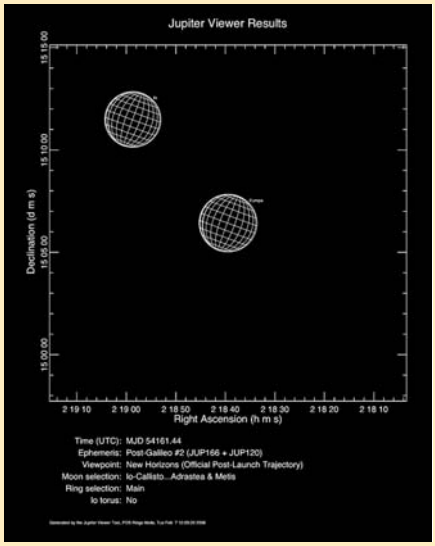
It's not just *Spirit* and *Opportunity* that get the attention of the amateur panorama-stitching crowd. Images from the polar lander *Phoenix* have had more than their fair share of Photoshopping, chopping, and mosaic-ing. Gordan Ugarkovic and Dan Crotty were probably not the first people to notice the sublimation of ice out of one of the trenches dug by *Phoenix*, but their posts on the forum were perhaps the first public airing of this unique discovery that truly clinched the ice claim inferred by *Mars Odyssey*.

Here in the United Kingdom, space and astronomy are best covered by the long-running TV program *The Sky at Night*. One episode about the *Phoenix* Mars lander featured an interview with one of the scientists from the Windsock experiment. In the background, on the wall of the offices from where *Phoenix* was commanded, I couldn't help but notice a large printout of a mosaic that seemed strangely familiar. On closer analysis, this was not a mosaic put together by the science team but one that enthusiast James Canvin assembled from the raw imagery on the *Phoenix* website.

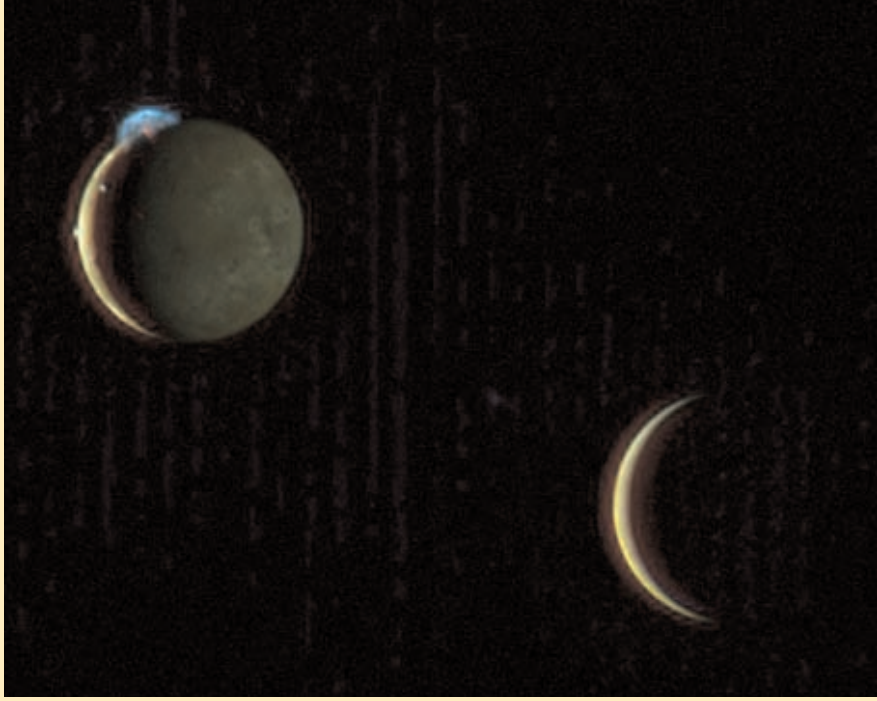
Beyond Mars

What about elsewhere in the solar system—what has this bunch of enthusiasts done beyond Mars?

The *New Horizons* spacecraft was launched in January 2006, and in 2007 it flew past Jupiter to get a slingshot boost on its flight to Pluto. To fully exercise the spacecraft during the flyby, the science team planned a lengthy sequence of scientific observations; however,



Because the* New Horizons *science team did not have time to plan for beautifully composed shots of the Jovian system, they enlisted UMSF members to help out in advance of the flybys. This graphic, as well as the one on the next page, details member Richard Hendricks' suggestions for what would become two of* New Horizons*' most famous images. *Graphics: Mark Showalter*



The Planetary Society's Emily Lakdawalla joined in by combining a low-resolution color image and a higher-resolution black-and-white one to bring us this view of volcanic Io and a crescent Europa. *Image: NASA/JHUAPL/Southwest Research Institute*

the team did not have time to identify any potentially attractive "Kodak moments." Science team member John Spencer visited the UMSF forum and asked if people there could suggest some. To help, he provided a link to an online tool that would show the Jovian system from the perspective of *New Horizons* during the flyby. One member, Richard Hendricks, suggested several interesting possibilities that made it into the sequence for the flyby. Forum members eagerly awaited the imagery, which the science team quickly posted to the Internet.

What images they were! Two images of the flyby that arguably are the most famous are both Richard's suggestions: Europa rising from behind Jupiter and, my favorite, Io and Europa in a single frame. Europa appears as a slim yellowish crescent and Io as a brighter crescent with the dark side filled in a little with "Jupiter shine." The image shows Io's volcanoes spewing forth, with an especially amazing Tvashtar throwing a plume high above Io.

To complete the circle of amateur participation, The Planetary Society's own Emily Lakdawalla combined a low-resolution color image and a higher-resolution black-and-white image to create a single sharp color image that demonstrates the beautiful, dynamic nature of the Jovian system (see image above).

Since the successful Jupiter flyby, John Spencer has returned to the forum and asked people to suggest observations for the Pluto flyby in 2015. As you can well imagine, suggestions have come thick and fast.

The *New Horizons* event happened roughly at the same time as Europe's *Rosetta* Mars flyby of 2007. Although *New Horizons* produced many stunning images, we have very few with which to enjoy the *Rosetta* flyby. What opportunities might have been missed? What image might have made the cover of newspapers and headlined on websites?

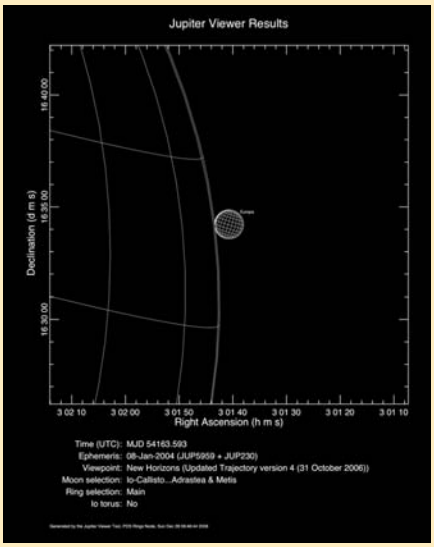
All is not lost here in Europe, however. *Mars Express* was fitted with a Visual Monitoring Camera (VMC) to observe *Beagle 2* being deployed. It's a low-resolution camera designed to produce single-shot color images. The camera was turned off after *Beagle 2* was deployed, shortly after taking the last image of that lost probe. The engineering team at ESOC in Darmstadt, Germany however, have since turned it back on and have scheduled imaging sequences between science sequences. It takes only a tiny amount of power, data, budget, and time, but the self-appointed "first webcam at Mars" has produced some great pictures. Raw, unpolished, and unprocessed, the images are released online. Within hours of the first posting, two different UMSF members had produced tools to process them into color images.

Not only does the engineering team put the "Photoshop food" out there, but they also actively invite people to submit their creations back to the VMC's website to be shared. One amateur observation caught what might have been a high-altitude cloud at the Martian terminator. The engineers have since gone back to the scientists and pointed it out; they even suggested that time might be made in the future for even more observations.

Amateurs and Professionals Working Together?

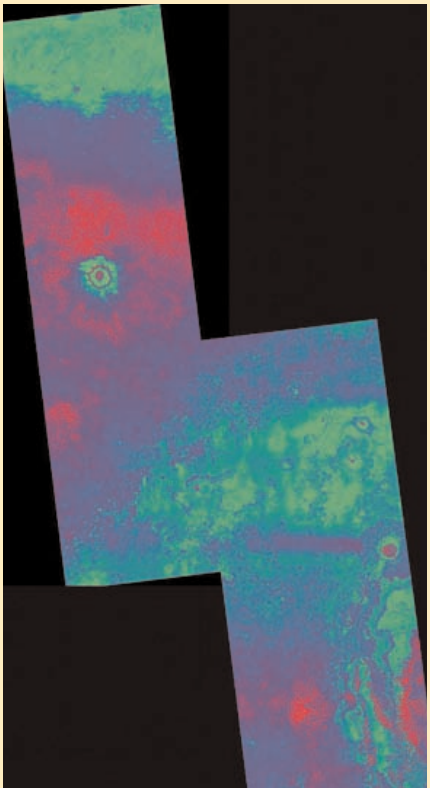
What is the future for communities like UMSF, and what are the possibilities for amateur involvement in real spaceflight operations?

Scott Maxwell, lead Mars Rover driver, gave a superb presentation at the Gnomedex conference in which he talked about Mars 3.0—his vision for how the science and engineering communities can better interface with the public via the Internet, not just as a means of communicating information but also to make it a two-way



This lovely portrait of Europa setting behind Jupiter is another of Richard Hendricks' suggestions to the* New Horizons *imaging team. *Image: NASA/JHUAPL/SwRI*

After the ill-fated* Beagle 2 *was deployed, the European Space Agency turned off its Visual Monitoring Camera (VMC) on* Mars Express. *The engineering team in Darmstadt, Germany has since turned it back on, and they are putting images online for people to process and send back to their website. Ted Stryk processed a raw, low-resolution VMC image of Mars into this more attractive view.
Image: ESA/Ted Stryk



When the MER team announced that* Opportunity *would make the trip from Victoria to Endeavour crater, several forum members analyzed HiRISE photos from* Mars Reconnaissance Orbiter *to see what sort of terrain the rover would have to navigate. Here's an example, by James Canvin, of the type of drivability maps that forum members produced.
Map: NASA/JPL/University of Arizona/ James Canvin

interface, through which the public can feel like a part of the adventure.

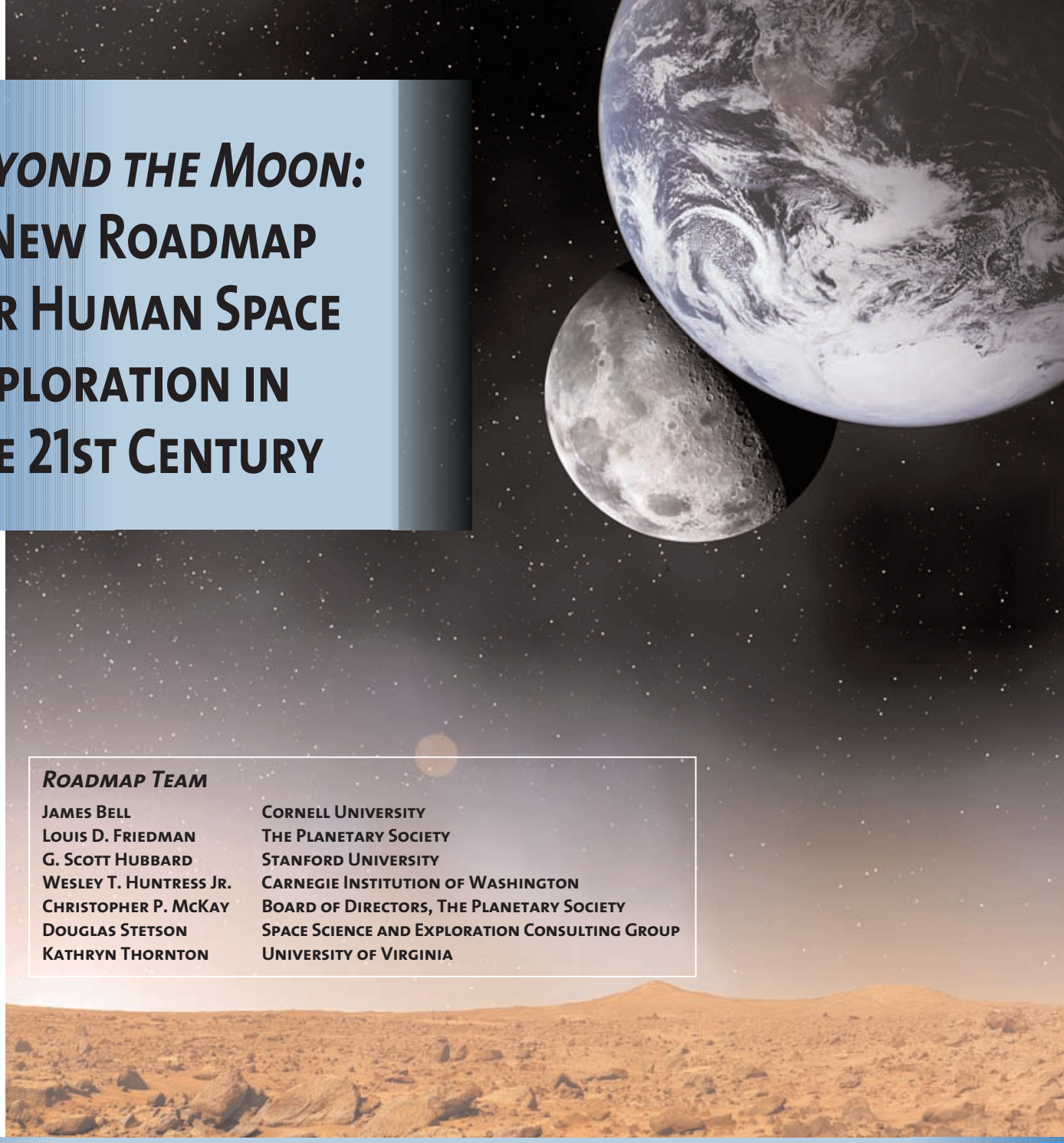
At the moment, red tape and decades of habit are restricting great progress in this area, but perhaps, in some small way, this process has already begun. After it was announced that *Opportunity* was setting out from Victoria crater for an epic journey to Endeavour crater, several forum members put their imaging and programming skills to work on HiRISE imagery from *Mars Reconnaissance Orbiter* to examine the driving terrain the rover would encounter. The resulting "drivability" maps, by James Canvin and others, closely correlate with the 12 kilometers (7 miles) of driving experience already covered. Even though the Rover driving team has its own tools for such analysis, this exercise demonstrated that amateurs have something of value to contribute.

The next rover to Mars, *Mars Science Laboratory*, will carry high-definition, video-capable cameras. A new fleet of spacecraft sent to the Moon surely will send back more data than their science teams will have time to analyze. What is certain is that because of the decision by Steve Squyres and Jim Bell in 2003, everyone at UMSF will have the opportunity to make the most of each bit of data that comes back.

Join us—it's an incredible ride.

Doug Ellison is the creator and host of the online forum unmannedspaceflight.com.

Beyond the Moon: A New Roadmap for Human Space Exploration in the 21st Century



Roadmap Team

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Christopher P. McKay	Board of Directors, The Planetary Society
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***The Planetary Society created* Beyond the Moon: A New Roadmap for Human Space Exploration in the 21st Century *as a contribution to the ongoing national discussion on the purpose, value, and implementation of America's space program. So far, the Roadmap has been presented to officials in NASA, in the U.S. Congress, and in the White House Office of Management and Budget, as well as to members of the transition team for President Obama. Due to space limitations,* The Planetary Report *is publishing only excerpts from the Roadmap. The complete Roadmap is available for download at* planetary.org/programs/projects/space_advocacy/roadmap.html.**

As the first decade of the 21st century draws to a close, the United States is poised at the threshold of unprecedented transitions and possibilities. More so than at any time since the end of the Cold War, the United States now has before it important opportunities to establish new directions for the nation and to help set the world down the path to a brighter, safer future.

There is an opportunity for American leadership of a peaceful international collaboration, embracing new participants as well as historical partners . . .

There is an opportunity to engage and motivate the younger, technically sophisticated generation that will lead the world with their discoveries and inventions . . .

There is an imperative to begin an aggressive campaign to understand global climate change and to address the challenges facing planet Earth . . .

And there is a critical need to inspire and unify the nation around a common purpose, one that is in keeping with the bold achievements of the past yet focused on new successes, doing what has never been done before.

The U.S. space exploration program provides the ideal context through which to achieve these goals. Long a source of pride and an important contributor to the national agenda, the space program is also at a time of transition.

Since the Vision for Space Exploration was proposed by President Bush in January 2004, NASA has been pursuing an implementation plan strongly influenced by its roots in the Cold War era and by the successes of the *Apollo* program some 40 years ago. Through a series of expert workshops, opinions widely expressed in the press and before Congress, and town hall meetings sponsored by The Planetary Society, sentiment has grown that the present plan may fail to realize the promise and potential articulated in the Vision. In fact, there is growing concern that today's strategy may result in little more than an expensive repeat and modest extension of *Apollo*-era achievements, with no clear path beyond them. To provide a foundation for an open debate and a new, forward-looking implementation plan, we articulate here a set of guiding principles and their implications for a new exploration paradigm.

Principles

The United States' human spaceflight program is an important and enduring symbol of global leadership as well as an engine for technology and innovation. It embraces and enables national and international interests, and it should be planned and conducted as an international endeavor.

Human spaceflight is a challenging endeavor that must be recognized and planned as a multi-decade program with clear long-term goals, stable funding, and sustained national commitment. Current implementation of the program has been hindered by an arbitrary and overconstrained schedule, inadequate funding, and a focus on short-term goals. This has led to compromises among the science and exploration objectives of the Vision for Space Exploration and a perceived competition with important Earth and space science initiatives.

Exploration of Mars should be the ultimate goal of human spaceflight in the foreseeable future. Mars exploration is a unifying objective worthy of a new global partnership for peaceful exploration of the planets and the universe beyond. The most effective and affordable plan is one that comprises scientifically and culturally important intermediate destinations, flexible program milestones, gradual development of new capabilities, and key robotic missions as stepping-stones to international human voyages to Mars.

Science, exploration, and technology are inseparable. A robust human spaceflight program will also yield unexpected and unique discoveries and new inventions. Science provides a framework for the technology that enables all exploration; our technology, in turn, defines our culture, educates our people, and drives our economy and national security.

Exploration and discovery represent a continuous and interactive process of science and adventure that is woven into the fabric of humanity. Robotic and human explorers working together in an integrated program will propel humankind toward its future in the solar system and will serve as a source of inspiration, achievement, and education for the people of planet Earth. The cultural and economic impact of expanding human horizons beyond our home planet, beyond Earth orbit, and beyond the Moon cannot be overstated . . . and the generation that finally makes that commitment will have defined the future of not just one nation or one people but of the entire human race.

Recommendations

Based on these principles and on the collective insight of the many individuals and groups who have participated in recent discussions, hearings, and open workshops, we offer the following recommendations for a robust, forward-looking space exploration implementation plan.

Establish a global space exploration partnership. The United States should engage the global community in a long-range program of human space exploration, based on a free and open exchange of ideas and results, shared costs, and broad participation and inspiration of the world's young people. An international investment strategy should be developed that is synergistic rather than duplicative, and within which the United States can focus its resources on the new transportation system and on capabilities for long-duration voyages beyond the Earth-Moon system.

Establish a program architecture leading humankind into the solar system. The National Space Council should be reconvened and chartered to examine and develop an exploration architecture, the ultimate goal of which should be establishing the capability for human exploration of Mars. This architecture should incorporate new, culturally significant scientific achievements as steps toward Mars, including:

- The first human voyages beyond the Earth-Moon system
- The first human voyages beyond the gravitational influence of Earth
- The first human exploration of near-Earth asteroids
- The first human voyages to another planet, culmi-

Montage: NASA/Loren A. Roberts, Hearken Creative

A flexible program will lead humankind beyond the Moon, into the solar system, and ultimately to Mars. An affordable international roadmap can be built from the achievement of important first-time goals, from new capabilities, and from key robotic missions.
Montage: Loren A. Roberts, Hearken Creative

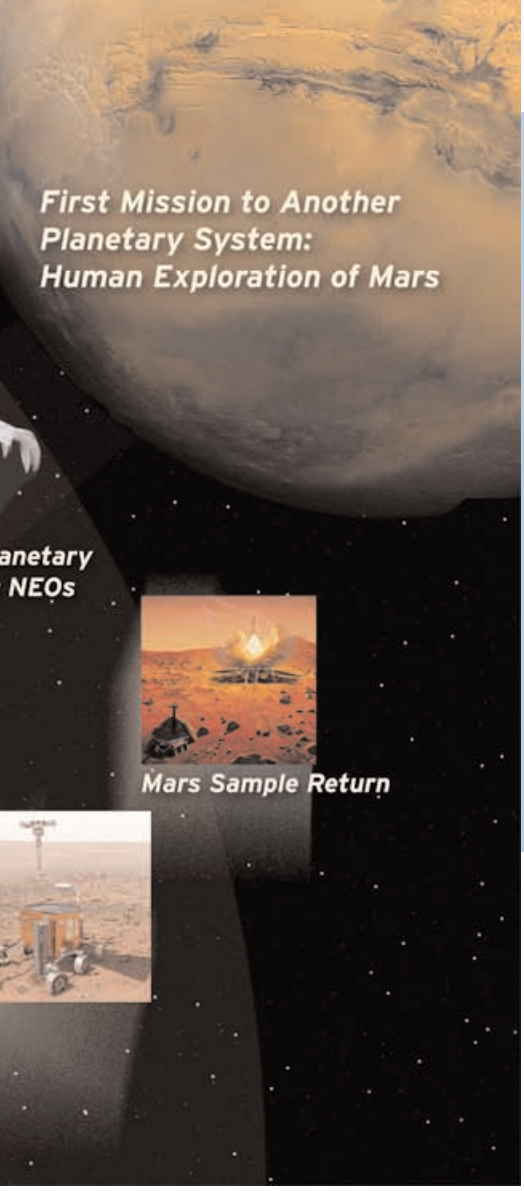
nating with a Mars landing and safe return to Earth

- The first human outpost on Mars with self-sustaining power and resources

The program architecture should be developed with full international participation and should incorporate flexible milestones so that artificial schedule constraints do not drive programmatic decisions. In particular, human landings on the Moon should be deferred until after a new transportation and interplanetary flight capability is developed and validated. They should be conducted at the appropriate time if they are shown to be critical steps toward the development and validation of exploration capabilities, but they should not a priori be designated as the first step.

Develop a national capability for human interplanetary transportation and life support. The system of launch vehicles, spacecraft, and supporting capabilities that will enable human missions beyond the Earth-Moon system is the most pressing development area, and it is one that will exercise and stimulate the American technological base. The new systems being planned now, known as Ares and *Orion*, have been designed primarily to meet the requirements of Earth orbit and lunar missions, and their extensibility to interplanetary destinations should be studied and revised if necessary. Further coordinated research and development investments should be directed at human factors and the ability of people to live and work for extended periods in deep space or at interplanetary destinations.

Pace human missions to the Moon based on need and in concert with international partners. The Vision for Space Exploration established a goal of new human lunar landings by 2020, and this has driven a series of programmatic decisions that may instead lead to multi-decade delays in the expansion of human activity beyond the Earth-Moon system. The present national economic situation exacerbates NASA's budget difficulties and makes it likely that the stated lunar exploration timetable cannot be met in any case. To mitigate this, human lunar landings should be deferred until after the costs of the new interplanetary transportation system and space shuttle replacement are largely paid and after that system has been utilized to conduct the first human missions beyond the Moon. The United States should then conduct human lunar surface missions if they are clearly shown to be the most cost-effective means of validating exploration techniques off Earth, or if lunar resources of compelling



Examining the Vision: Balancing Science and Exploration

In February 2008, The Planetary Society and Stanford University sponsored a workshop at Stanford, bringing together nearly 50 experts, including top scientists, former NASA officials and astronauts, industry executives, and space policy specialists. This created an environment in which insights across traditional boundaries could occur and offered an opportunity for frank and open discussion of the Vision for Space Exploration and other important space and Earth science priorities.

Among the conclusions of this group is that "the purpose of sustained human exploration is to go to Mars and beyond" and that a series of intermediate destinations, each with its own intrinsic value, should be established as steps toward that goal. The consensus statements and viewpoints expressed by this group of experts form the basis for the principles and recommendations contained in the Roadmap.

economic benefit are discovered. Our focus should be on teaming with, not competing against, the international space agencies whose priorities include lunar exploration on their own time scales. The United States should continue to invest in robotic lunar science missions and should encourage new commercial ventures that seek to mount private lunar missions.

Ensure that robotic space and Earth science initiatives are protected and enhanced. Space science research and the observation of Earth from space are perhaps the most significant and productive elements of the U.S. scientific portfolio. These must be continued and should be enhanced when possible. Planning should be coordinated across the robotic and human space exploration programs to ensure that both can take advantage of the many important synergies. Special emphasis should be placed on identifying the proper mix of human and robotic exploration elements and on understanding the best role for human explorers in the fulfillment of scientific objectives. While pursuing international collaboration for human space exploration, the United States should strive to engage its partners in a new thrust to understand threats to planet Earth, including global climate change and potential asteroid impacts.

Outline of a New Implementation Plan

One of the major criticisms of post-*Apollo* American human spaceflight has been the lack of clear long-term focus, purpose, and destination. Stemming from the loss of the space shuttle *Columbia* and the resulting report of the *Columbia* Accident Investigation Board (CAIB), the Vision for Space Exploration recognized the need for and value of a long-range plan for the expansion of human activity into the solar system.

Unfortunately, NASA's implementation of the Vision has been focused no farther than the Moon, a destination the United States first reached nearly 40 years ago. Though not precluding a return to the Moon in concert with international partners, the incoming administration should consider an alternative plan that makes demonstrable progress toward new destinations and new achievements in a flexible, affordable manner. While continuing to make progress toward the new launch and crew systems that will replace the space shuttle, the plan should also include the following elements:

Demonstrate deep-space capability. With relatively modest changes, the current Ares and *Orion* designs could be used to enable 15- to 30-day deep-space missions rather than lunar missions. As the first-ever human missions to the edge of or beyond the gravitational influence of Earth, these would be significant cultural milestones as well as major technical steps toward our long-term presence in the solar system. Because it would not require the simultaneous development of expensive lunar surface infrastructure, this plan would relieve pressure on NASA's budget.

Make the first human interplanetary voyage. A natural first step into interplanetary space would be a mission to a near-Earth object (NEO). Because NEOs

Ares and Orion, *NASA's planned launch and crew exploration vehicles, should be studied and revised, if necessary, to extend their capabilities beyond Earth and lunar orbit. Here the final piece of the outer shell for an* Orion *mock-up is lowered into place in October 2005.* Photo: NASA

Right: It is imperative that the United States and other nations undertake a broadly based effort to understand global climate change and the challenges facing Earth. An international partnership can help to ensure that robotic space and Earth science initiatives are protected and enhanced. Image: NASA

are relatively close to Earth, these missions could be accomplished by extending the capabilities of the currently planned Ares crew and cargo launch systems and the *Orion* exploration vehicle, again without the added burden of expensive infrastructure for lunar surface exploration. Validation of the interplanetary transportation and human support systems on a four- to eight-month mission to an NEO would be a critical step forward and would demonstrate U.S. vision and leadership in human exploration and utilization of the solar system.

Develop and demonstrate new capabilities for exploration and human support. As the new transportation system is developed and utilized on the first human deep-space missions, the United States and its international partners should expand investments into new techniques to support future exploration. This should include landing systems and habitats for an eventual mission to Mars, life-support and resource utilization systems, information technologies, sensors and scientific instruments, and other elements of a long-term human presence in the solar system. This initiative should also encompass use of the International Space Station for dedicated research on the biological effects of long-duration stays in deep space.

Conduct key robotic science missions. Human expansion into the solar system will rest on the scientific foundation provided by the robotic planetary missions of NASA and international space agencies. The United States should enhance its planetary science program in an international initiative to encompass new robotic missions that will serve as important precursors to future human exploration. These include robotic surveys of NEOs to identify resources and enhance planning for human missions; robotic missions to the Moon for science, resource assays, and technology validation; and expanded robotic missions to Mars. In particular, missions to return samples from key locations on Mars should be conducted prior to extensive investment in planning human Mars missions.

Continue planning for eventual human exploration of Mars. The long-range vision for the human exploration of Mars provides the context for these investments and precursor missions, and NASA's implementation plans should be revised to reflect this commitment. Although it is premature at this point to commit to a specific timetable for missions to Mars, it is important that we declare that we are ready to start the journey. The flexible sequence of technical developments, culturally significant milestones, and new achievements outlined here can enable the incoming administration to establish a new paradigm for the U.S. human space exploration program and a global focus for the world's spacefaring nations.

Accelerate research into global climate change and enhance our understanding of Earth as a planet. Concurrent with the restructured initiative for international human space exploration, the United States must begin an aggressive campaign to understand global climate change and address the challenges facing planet Earth. Although it is not the subject of this document, broad consensus has emerged that Earth science research has been undervalued in the NASA portfolio in recent years and must be augmented, both in terms of budget and as an element of national space policy. The combination of human voyages away from Earth and the imperative to better understand and care for our home planet can be a unifying principle, a context for peaceful international cooperation, and an unmatched legacy that this generation can leave for posterity.

Program Planning and Budget

A new implementation plan should continue to focus in the near term on the development of the launch and crew

The first human voyage to Mars, culminating in a safe return to Earth, is a challenging goal in keeping with the great successes of the past, yet focused on new achievements. The first steps toward this future need to be taken today. *Illustration: NASA*

systems that will replace the space shuttle, but it should shift toward early utilization of those systems for the first human voyages into deep space rather than an immediate return to the lunar surface. This new approach will offer three important benefits.

First, it will relieve pressure on NASA's budget, since development of new lunar surface capabilities can be postponed. The resulting programmatic flexibility should be used to advance the development of the Ares/*Orion* systems in order to minimize the interval between their readiness and the retirement of the space shuttle in 2010. Delay in the onset of a new human lunar program will allow time for the lunar exploration plans of other nations to mature, as well as for the development of true international partnerships for exploration of the Moon and beyond. It will also allow time for nascent commercial launch options and lunar initiatives to reach fruition. The success of these international and commercial endeavors should have a major bearing on whether and how the United States decides to return to the Moon with human explorers.

Second, it will help to ensure that the new launch and crew systems have maximum applicability to the long-term goal of human expansion into the solar system and, ultimately, to conducting human missions to Mars. To reinforce this commitment, planning should begin immediately for the initiation of new research thrusts into bioastronautics and human factors using the International Space Station, and for the development of technologies for future human missions to deep space and to Mars. This should encompass planning for key robotic science missions including Mars sample return. It is important that this future planning be done concurrently with the development of the launch and crew systems so that the end result is a system architecture with all the capability required to venture successfully into interplanetary space.

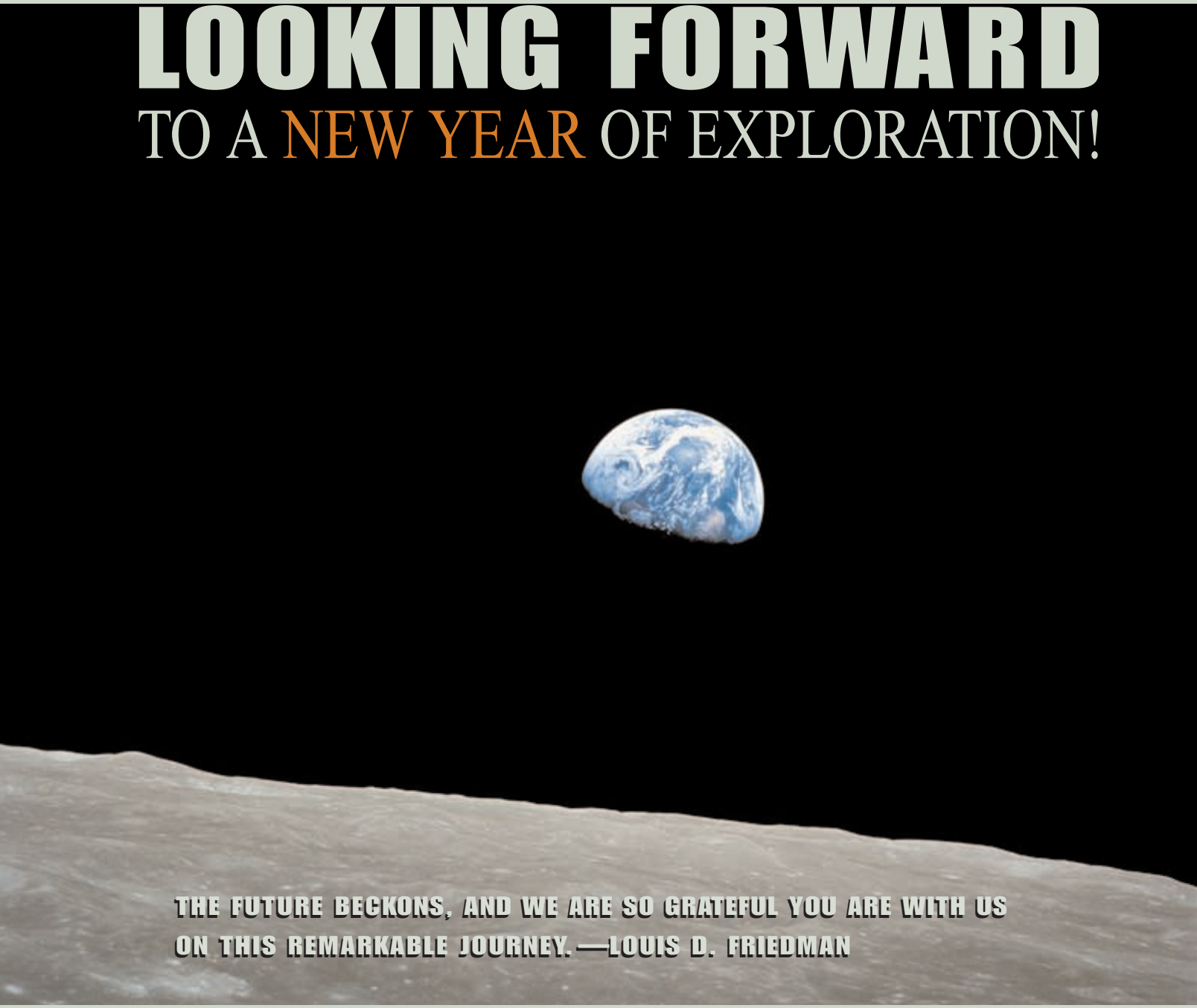
Finally, this approach will demonstrate to the American public and to the international community that the United States is committed to maintaining its leading role in pioneering the frontier of space. It will instill a new sense of pride and purpose in America's human space program and return to it the responsibility of pushing the boundaries of ingenuity and technology to reach challenging goals for the first time. Having invited the world's spacefaring nations to join in a partnership for space exploration, the United States can also help to direct this spirit of cooperation to other important areas.

NASA does not require a large budget increase to enable the program described here. Deferral of the expensive human lunar landing program will ease budget pressures while still enabling important first-ever achievements in space. NASA should be provided with a stable budget commensurate with the level recently established by the NASA Authorization Act of 2008. At that level—approximately $19B in FY09, keeping pace with inflation thereafter—a properly structured program with flexible, performance-driven milestones and international collaboration can make excellent progress toward a long-term human presence in the solar system.

The human imperative to experience and understand our planetary neighborhood will continue, as it has for generations. Space exploration carries with it the promise of a hopeful future, and the time to take the next bold step into that future is now.

The Planetary Society released Beyond the Moon: A New Roadmap for Human Space Exploration in the 21st Century *in November 2008. Learn more about our workshop, town hall meetings, and Roadmap at* planetary.org/programs/projects/space_advocacy/.

LOOKING FORWARD
TO A NEW YEAR OF EXPLORATION!



THE FUTURE BECKONS, AND WE ARE SO GRATEFUL YOU ARE WITH US ON THIS REMARKABLE JOURNEY. —LOUIS D. FRIEDMAN

Happy 2009!

The beginning of a new year offers us a fresh slate to fill as we enter a time of both transition and hope. Change is afoot in the world, including in how nations embark on the adventure of space exploration. The Planetary Society will help to chart that voyage to the future.

The future holds uncertainty for us all, and space exploration is no exception. The world economic situation is critical, as are the increasingly noticeable effects and looming implications of global climate change. These are challenges that the nations of the world must meet together, and they have the potential to foster greater international cooperation.

Creating a global perspective is one of the chief benefits of space exploration, as we are reminded this month by the 40th anniversary of the iconic "Earthrise" picture taken by *Apollo 8* as it orbited the Moon in 1968. The International Space Station, which celebrated its 10th anniversary this year, is another example of an engineering and political achievement that united several nations in the peaceful pursuit of exploration.

From The Planetary Society's inception in 1980, a global perspective has been our hallmark. We reaffirmed that outlook this past year with our new Roadmap for Human Exploration (see page 10). Its number one recommendation is to "Establish a global space exploration partnership."

NASA and ESA recently announced their intention to recast Mars exploration as an international venture. We hope that 2009 and the decade that follows will find the world even more united in a coordinated journey to other worlds.

Wrapping Up a Successful Year

The year 2008 was filled with many achievements for The Planetary Society.

In November, we presented our Roadmap to the Obama transition team that is organizing the new U.S. administration's plans for NASA. Our Roadmap has generated intense interest in both space circles and the media. The Roadmap was the result of a nine-month process of examining the Vision for Space Exploration, beginning with a workshop of experts at Stanford University and followed by a series of town hall meetings in the United States and abroad.

In May, we landed the first "library" on Mars, on board the *Phoenix* spacecraft. In it were the hopes and dreams of science fiction writers and astronomical artists, as well as those of our members, who sent this gift to the future explorers of Mars. Our message from Earth, *Visions of Mars*, landed with the spacecraft near the Martian north pole, bringing with it the works of Isaac Asimov, Ray Bradbury, and Arthur C. Clarke and the names of all Planetary Society members. We are grateful to NASA, JPL, and the University of Arizona *Phoenix* lander team for carrying this first library to Mars.

Throughout 2008, The Planetary Society stepped up its efforts in support of Earth observations from space. We joined the Alliance for Earth Observations and devoted an entire issue of *The Planetary Report* to Planet Earth. In 2009, we will focus more publications and activities on this vital subject.

In February, we announced the winners of our Apophis Mission Design competition. The resulting worldwide attention demonstrated to the media and the public the dangers posed by near-Earth objects (NEOs). We also continued to support both amateur and professional astronomers engaged in the search for and tracking of NEOs through our Gene Shoemaker grants.

The International Lunar Decade, which we proposed, is off to a great start. Japan, China, and India all sent successful spacecraft into lunar orbit. The space agencies are now working on a plan for an International Lunar Net as the next stage, with new lunar landers planned for the coming decade.

Apollo 8 *photo of Earth taken from the surface of the Moon.* Image NASA

Looking Ahead to a Year of Change

The Planetary Society has more remarkable plans for 2009 and for the next decade. We're dedicated to continuing the work we have been doing since our inception—influencing the world's space programs, funding cutting-edge projects, and finding ways for you to play an active role in space exploration. As we look forward, we are also making bold changes to enable us to do more.

In 2009, our Living Interplanetary Flight Experiment (LIFE) will be prepared for launch aboard Russia's *Phobos-Grunt* mission. Our experiment will test if microbes can survive a long journey between worlds.

We will continue to support the Search for Extraterrestrial Intelligence (SETI) with radio observations in Argentina and with optical observations in Harvard, Massachusetts. These dedicated searches are unique, and thanks to support from our members, we'll be able to provide much-needed upgrades to both SETI efforts.

We have more to do with our Roadmap. In early 2009, we intend to present our plan for space exploration to the U.S. Congress. Soon we will announce a new advocacy campaign for widespread public support for space exploration—both human and robotic exploration.

We also remain committed to launching the first flight with light on a solar sail. We are considering new options and hope to soon commit to a new flight.

In the next year, you can also expect the Society to take on new activities with extrasolar planets missions, missions to a near-Earth asteroid, and support for a flagship mission to the outer planets. We will continue to lead by seeding new exploration and advocating great missions.

The Society, like the United States, is undergoing a transition in leadership: planetary scientist Jim Bell agreed to serve as our new president, and he will bring the energy and dedication to our organization that he has demonstrated as leader for the Mars Exploration Rovers Pancam team. Neil deGrasse Tyson, while stepping down as president, renewed his commitment to The Planetary Society and continues to serve on our Board of Directors. Our well-known vice president, Bill Nye the Science Guy®, will stay actively involved in all we do.

We will also be changing our address. The Society's headquarters in Pasadena—which you, our members, helped purchase—has been an incredible investment. Maintaining our aging 1903 Craftsman house, however, requires far more repairs and upkeep than we want to commit from Society funding. We have decided to sell the building now, while our property is still worth three times as much as we paid for it, and because it is an advantageous time to acquire new space for our headquarters. After we relocate, we will reinvest the proceeds from the house to build new Society programs to help us advance our mission: new projects to further exploration, new ways to build a space interest community, and new initiatives to aid in our understanding of our planet and about our place in the cosmos.

Space exploration creates a positive future for our generation and for our children's generation—and The Planetary Society helps create space exploration. The year 2009 will indeed be a time of change, both difficult and exhilarating. Global challenges will create global opportunities. With our Members behind us, The Planetary Society remains committed to investing in the future. We need your support now more than ever as we change and grow.

The future beckons, and we are so grateful you are with us on this remarkable journey. Thank you for your support and for your part in making space exploration happen.

Louis D. Friedman is executive director of The Planetary Society.

Celebrating Five Years on Mars!

by Bruce Betts

After a drive of more than 150 meters on sol 1,663,* Opportunity *took a day of rest to look around and contemplate its tracks on the rippled sand of Meridiani Planum.
Image: NASA/JPL

Amazingly, it is time to wish the Mars Exploration Rovers (MERs) a happy fifth anniversary—not bad for nominal 90-day missions. Both rovers, *Spirit* and *Opportunity*, continue to send scientists breathtaking images and important scientific data while engineers and project managers keep the rovers rolling. It seems hard to believe that it has been five years since we were at The Planetary Society's Wild About Mars celebration, where more than 2,000 people came together in Pasadena to witness the *Spirit* landing. We hardly could have guessed that five years later, we would still be following the successes of this intrepid explorer and its sister rover.

The Planetary Society and its members are part of this historic mission. Each of the two MER landers carried a DVD provided to NASA by The Planetary Society. These DVDs contained the names of the then-current members of The Planetary Society as well as those of millions of other people who wanted to send part of themselves to Mars.

The Planetary Society is connected with the rovers in more ways: the Society's new president, Jim Bell, is the leader of the Panoramic Camera color imaging team for the Mars Exploration Rovers. Jim—who has written two books about the rovers' adventures on Mars, *Postcards from Mars* and *Mars 3-D*—assumed the helm of The Planetary Society in October 2008.

Another Planetary Society contribution to the mission was Vice President Bill Nye's suggestion that the camera calibration targets on the rovers be made into sundials. MER Principal Investigator Steve Squyres agreed, and Louis Friedman coined the motto that was written on each MarsDial: "Two Worlds, One Sun." Now, wherever the rovers roam, they both carry an age-old measuring device for time.

Because the rovers are moving platforms, the MarsDials have no hour markings. That's where The Planetary Society's Student Astronauts played a role. During the time of the MER landings, 16 young people from 12 countries worked at the Jet Propulsion Laboratory (JPL) in four-person teams to process the MarsDial images, adding the hour markings. These talented students, who ranged in age from 13 to 17, were the third group of young engineers and scientists that The Planetary Society engaged in hands-on space exploration programs as part of its Red Rover Goes to Mars project. You can find out the impressive places these young people are now and what some of them are doing at *planetary.org/programs/projects/space_information/5years.html*.

The Planetary Society even helped name the rovers, through a contest we ran with the LEGO Corporation and NASA. Sofi Collis—then just nine years old—came up with the winning entry of *Spirit* and *Opportunity*.

For all five years, The Planetary Society has been closely following the adventures of these Martian explorers on our website, on our blog, and on Planetary Radio, and we will continue to do so.

We congratulate the thousands of people who have worked directly on the MERs, and we thank NASA, JPL, LEGO, and our many other partners for facilitating The Planetary Society's participation in these missions.

We can't wait to see what's going to happen next!

Bruce Betts is director of projects for The Planetary Society.

Planetary Society and the Mars Exploration Rovers

DVDs on Mars—Each of the two Mars Exploration Rover spacecraft carried a DVD provided to NASA by The Planetary Society. This was only the second time that privately contributed hardware flew on a U.S. planetary mission. (The first was The Planetary Society's Mars Microphone on the *Mars Polar Lander*.) The DVDs were mounted on the *Spirit* and *Opportunity* landers. Each rover acquired several images of the individual DVDs before embarking on its own historic journey across Mars, leaving the landers and the DVDs behind.

MarsDials—The Mars Exploration Rovers each carry identical sundials, approximately three inches in length and width. Space artist Jon Lomberg (a Planetary Society adviser) designed the face of the MarsDial, and Louis Friedman, the Society's executive director, coined the MarsDials' motto: "Two Worlds, One Sun." Their primary function is to serve as calibration targets for the high-resolution Panoramic Cameras aboard each rover, so they are imaged frequently over the course of the mission. These thousands of images of the MarsDials, with their moving shadows, also serve to remind the public that Mars and Earth truly are two worlds with one Sun.

Name the Rovers—The Name the Rovers contest provided students with the opportunity to find a place in history by naming the Mars Exploration Rovers. The contest was managed by the LEGO Company and The Planetary Society in conjunction with NASA. Nearly 10,000 entries were received. LEGO and The Planetary Society winnowed these to 34 contest winners, whose entries and supporting essays were forwarded to NASA for further consideration. NASA selected the Grand Prize Winner, nine-year-old Sofi Collis, for her entry of *Spirit* and *Opportunity*, announcing the new names just before *Spirit*'s launch on June 7, 2003.

Student Astronauts—The students of today are the explorers of tomorrow! With the Red Rover Goes to Mars project, The Planetary Society and the LEGO Company partnered to provide hands-on opportunities for students around the world to participate directly in real missions to Mars. In 2001, nine Student Scientists became the first members of the public to direct a camera on board a spacecraft orbiting another world, NASA's *Mars Global Surveyor*. In 2002, eight Student Navigators trained for the Mars Exploration Rover mission through a two-day training program at the Jet Propulsion Laboratory (JPL) with the FIDO prototype rover. In 2004, 16 Student Astronauts joined the science team at JPL to participate directly in the daily operation of *Spirit* and *Opportunity*. Through their online journals, the Student Astronauts served as Mars exploration ambassadors to the world at large.

What's **Up?**

In the Sky—February and March 2009

Venus is the extremely bright starlike object in the west in the early evening throughout February, getting lower toward the horizon through March. On February 27, the crescent Moon will appear next to Venus. Saturn rises in the mid-evening in Leo. In the predawn sky, bright Jupiter grows higher in the east from late February through March, and Mars gradually grows higher (below Jupiter). On February 22, Jupiter (brightest), Mercury (next brightest), and Mars are all within a 5-degree circle and are near the thin crescent Moon, but all will be very low toward the horizon in the east just before dawn. On March 25, Venus is technically both in the evening sky and the predawn sky, a rare event that occurs only every eight years. The trick is, it will be extremely low in both and therefore hard to observe.

Random Space Fact

Solar eclipse watchers are lucky to live in a time when the apparent sizes of the Moon and Sun are very similar, enabling the Moon to block out the Sun in a total solar eclipse. Both bodies are about 0.5 degrees of arc in the sky. But the Moon is getting farther from the Earth over time (by a few centimeters per year), just as the Earth's day is getting longer, both due to energy dissipated by tidal effects. The day is getting longer very slowly by human standards—a leap second is added to our year to account for this every few years, including one between 2008 and 2009.

Trivia Contest

Try to win a free year's Planetary Society membership and a Planetary Radio T-shirt by answering this question:

Including the initial launch, and as of the end of 2008, how many space shuttle missions have been flown to the Hubble Space Telescope?

E-mail your answer to *planetaryreport@planetary.org* or mail your answer to *The Planetary Report*, 65 North Catalina Avenue, Pasadena, CA 91106. Make sure you include the answer and your name, mailing address, and e-mail address (if you have one).

Submissions must be received by May 1, 2009. The winner will be chosen by a random drawing from among all the correct entries received.

For a weekly dose of "What's Up?" complete with humor, a weekly trivia contest, and a range of significant space and science fiction guests, listen to Planetary Radio at *planetary.org/radio.*

Questions and Answers

Is there any way of finding out the depths of some of the ethane/methane lakes on Titan?
—Mike Martinez
Inver Grove Heights, Minnesota

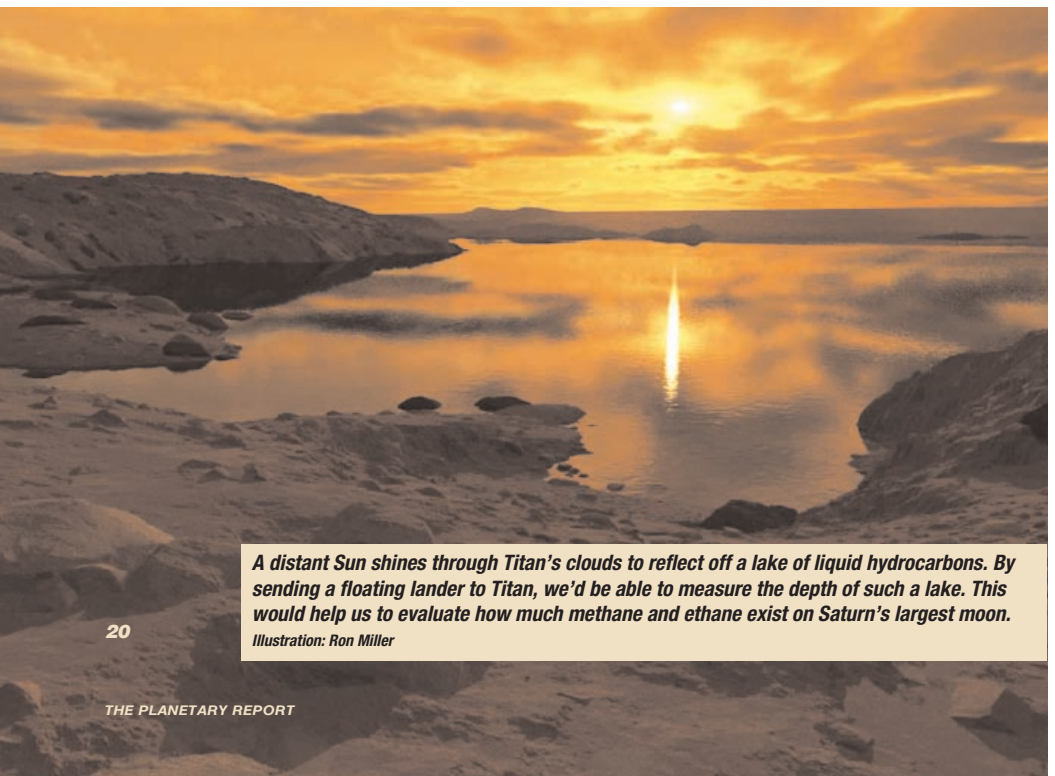
This is an important question, because measuring lake depths on Titan would allow us to evaluate the amount of methane and ethane on Saturn's largest moon. This in turn would help us understand Titan's methane cycle, which is very similar to our own hydrologic cycle on Earth.

The centers of most of Titan's lakes are quite dark in *Cassini* radar data (indicating almost no radar return). This tells us that the lakes are at least several meters deep, because radar has the ability to penetrate several meters through liquid methane. We do see increased brightness in the radar data at the edges of many of the lakes, which may indicate that we are penetrating through the liquid hydrocarbons to the lake bottom.

The only way to obtain such a measurement would be to send a lander equipped with a sonar that could measure the depths of Titan's lakes the same way that we measure lake and ocean depths on Earth. The *Huygens* lander actually was equipped with such an instrument because of the possibility that it might land in one of Titan's seas.

Sending a (floating) lander to a lake on Titan is a high priority for future Titan exploration!

—ELLEN STOFAN,
Proxemy Research



A distant Sun shines through Titan's clouds to reflect off a lake of liquid hydrocarbons. By sending a floating lander to Titan, we'd be able to measure the depth of such a lake. This would help us to evaluate how much methane and ethane exist on Saturn's largest moon.
Illustration: Ron Miller

How is it that Earth's big storms are low-pressure (cyclonic) while Jupiter's are high-pressure (anticyclonic)?
—Kevin McCloskey
Philadelphia, Pennsylvania

Earth and Jupiter do appear to be quite different when it comes to their biggest storms. Earth is dominated by low-pressure hurricanes and Jupiter by its high-pressure Great Red Spot and similar windstorms. On closer inspection, however, the two planets' similarities far outweigh their differences.

When Shakespeare wrote "All the world's a stage," he could have been talking about meteorology, which, in many ways, resembles a ballet played out on a globe. Surface area, which makes for horizontal elbow room, is the primary difference between Jupiter and Earth. Jupiter has more than 120 times as much real estate as Earth and, consequently, the great storms on its surface are able to spin gracefully, like a company of ballerinas dancing Swan Lake on a grand stage.

The natural horizontal length scale (the storm or eddy size) in Earth's atmosphere is 1,000 to 2,000 kilometers (about 600 to 1,200 miles) in length—similar to that in Jupiter's. This means that Earth has the same ballerinas trying to dance *Swan Lake*, but in an elevator. Ouch.

Our planet's atmosphere receives more solar energy per square foot than any other planet (even Venus, which is closer to the Sun but has more reflective cloud cover) and yet has the slowest jet streams in the solar system. Earth's global circulations simply do not have the elbow room one finds on the gas giants. It is no accident that the Antarctic circumpolar current—which inhabits the only latitude where water can circumnavigate the globe unimpeded by coastlines—is the strongest in Earth's oceans and most like Jupiter's jet streams.

It is in our oceans where the real answer to the question lies. Earth is a "giant planet," not because of its atmosphere but rather because of its oceans. The same eddy length scale in the oceans is about 100 kilometers (about 60 miles) and the consequence is that Earth's ocean basins are as giant as Jupiter when gauged in relationship to the size of their eddies.

Where, then, are Earth's oceanic Great

Red Spot and White Ovals? Right there, one kilometer (0.6 mile) under the surface of the Atlantic Ocean. Salty Mediterranean seawater slides down into the Atlantic and breaks off, forming beautifully shaped, high-pressure lenses (vortices under the surface of the ocean) called Mediterranean Salt Lenses, or "Meddies" for short. These can now be detected by satellites due to the minute changes they make to sea surface height. Oceanographers have succeeded in placing neutrally buoyant Sound Fixing and Ranging (SOFAR) floats into Meddies and tracking them for years. This is remarkable for Earth, where weather patterns, even great hurricanes, have lifetimes measured in days. Deep in the oceans, however, all the grace and grandeur of Jupiter's atmospheric dynamics is playing out year in and year out.

Although Earth's Meddies are mathematically similar to Jovian storms, our planet's atmosphere does have a strong analogy itself, called *blocking highs*. These stubborn, high-pressure systems often settle over the continental United States and Russia. They earned their name because they block the normal track of rainstorms.

One variety of blocking high is called the Ring of Fire. In this case, "fire" refers to thunderstorms that are forced to go around the anticyclone. Droughts occur in the middle of a blocking high, and flooding occurs around the periphery. If the energy in Earth's atmosphere was spread out more, it would let these features persist for years, as they do in the oceans or on the gas giants, and not shred them after a month or two, as is always their fate.

Jupiter does have cyclones but not hurricanes, mainly because the planet has no abrupt surface to provide a frictional boundary layer that is crucial to the circulation of a hurricane. In a nutshell, Meddies and the Great Red Spot are much simpler than a hurricane: they are just vortices, and their high pressure helps balance them in a robust manner. Jupiter's cyclones have amazing life cycles in which convective thunderstorms suddenly appear in their centers (presumably when they drift over patches of deep, moist air) and then explode like giant bombs, blowing the circulation apart into filamentary cyclones. Eventually these loose jumbles settle back down, and the whole life cycle repeats itself.

Planetary scientists are making great strides in modeling the different types of storms on the gas giants and comparing them with those on Earth, which will benefit our understanding of both types of systems.

—TIMOTHY E. DOWLING,
Comparative Planetology Laboratory

Factinos

The debris around dead stars is helping scientists to understand the evolution of planets. Observations from the Spitzer Space Telescope show that the regions surrounding six white dwarfs—the skeletal remains of dead stars—are littered with the leftovers of shredded asteroids. So far, the findings suggest that the same materials that formed our solar system's rocky bodies might be common in the universe. If the materials are common, then rocky planets might be as well.

"If you ground up our asteroids and rocky planets, you would get the same type of dust we are seeing in these star systems," said Michael Jura of the University of California, Los Angeles. Jura presented the report at the American Astronomical Society's January meeting in Long Beach, California. "This tells us that the stars have asteroids like ours—and therefore could also have rocky planets," he said. Jura is the lead author of a paper on this discovery that has been accepted for publication in the *Astronomical Journal*.

Sometimes a white dwarf's gravity will rip apart an asteroid that comes too close, much as the way Jupiter's gravity broke up Comet Shoemaker-Levy 9 in 1994.

Research with the Spitzer Space Telescope found that the asteroid dust contains a glassy silicate similar to olivine and commonly found on Earth. The data also suggest that there is no carbon in the rocky rubble, which is, again, similar to the asteroids and terrestrial planets in our solar system, which have relatively little carbon.

—from NASA

Our home galaxy is more massive, moving faster, and more likely to get into a collision than we realized. Scientists using the Very Long Baseline Array (VLBA) radio telescope have found that the Milky Way is rotating about 161,000 kilometers (100,000 miles) per hour faster than has been previously understood. That increase in speed, said Mark Reid of the Harvard-Smithsonian Center for Astrophysics, increases the estimate of the Milky Way's mass by 50 percent, bringing it even with the Andromeda Galaxy. "No longer will we think of the Milky Way as the little sister of the Andromeda Galaxy in our Local Group family," Reid noted. The larger mass, in turn, means a greater gravitational pull that increases our chances of a collision with Andromeda or smaller nearby galaxies.

Our solar system sits about 28,000 light-years from the Milky Way's center. At that distance, the new observations indicate, we're moving at about 966,000 kilometers (600,000 miles) per hour in our galactic orbit, up from the previous estimate of 805,000 kilometers (500,000 miles) per hour.

Reid and his colleagues also measured the distances to multiple regions in a single spiral arm, allowing them to calculate the angle of the arm, which led them to another surprise. "These measurements," Reid said, "indicate that our galaxy probably has four, not two, spiral arms of gas and dust that are forming stars."

—from the Harvard-Smithsonian Center for Astrophysics

Society News

The International Year of Astronomy

The Universe, Yours to Discover

The new year ushers in the International Year of Astronomy —a global effort to help the citizens of the world rediscover their place in the universe. A staggering 135 nations are collaborating to bring the universe closer to Earth, providing events and activities that will take place throughout 2009.

The International Year of Astronomy 2009 (IYA2009) was initiated by the International Astronomical Union (IAU) and the United Nations Educational, Scientific, and Cultural Organization (UNESCO) under the theme "The Universe, Yours to Discover."

For The Planetary Society, IYA2009 is a continuation of the mission we have pursued since 1980. IYA2009 gives us an opportunity to bring our message to people around the world, to involve them in the increasingly international fleet of planetary exploration missions, and to encourage more of them to take action to increase peaceful space exploration and decrease the risk posed to the inhabitants of Earth by threats from space.

We hope that the worldwide events of IYA2009 will focus public attention not only on distant stars and galaxies but also on our own solar system. Space is not just what we see at the other end of a telescope; we live in space, too, and it is as important to study our own neighborhood as it is to examine the universe beyond.

—Emily Stewart Lakdawalla, Science and Technology Coordinator

Do We Have Your E-Mail Address?

If you haven't received an e-mail from us in the last few months, we don't have your e-mail address. Please write us at *members@planetary.org* or go to *planetary.org/emailupdate*, and we will make sure your e-mail address is added to your membership information.

Your e-mail address is your ticket to exciting space information and activities. Each month, we will send you notices about upcoming programs, Planetary Society projects, events, and news in the space community.

Don't worry—we will never sell or share your e-mail address.

Stay informed by staying connected with The Planetary Society.

—Monica Bosserman Lopez, Marketing and Interactive Manager

Your Gift Planning Today Can Shape Tomorrow's Future in Space

When you watch the images returned from Mars or see our own planet viewed from space, look out into the universe and wonder if we are alone, or marvel at the discovery of yet another extrasolar planet, you are experiencing the joy of space exploration and our search for our place in the cosmos.

As someone who cares about our planet and those beyond, you have joined with The Planetary Society to search for other life and other worlds today, and you can help us leave a space exploration legacy for future generations.

By planning your gift today—naming The Planetary Society as a beneficiary in your will or estate plan—you can make a significant gift for space exploration tomorrow.

Your bequest to The Planetary Society helps ensure that we can meet new challenges and opportunities. You have a hand in shaping the future of space exploration, and in many countries, you will also receive significant tax benefits. In every case, you will feel good knowing that you are making a difference for future explorers like yourself.

For information on including The Planetary Society in your will or estate plan, please call Andrea Carroll, Director of Development, at (626) 793-5100, extension 214, or e-mail me at *andrea.carroll@planetary.org*.

—Andrea Carroll, Director of Development

Erratum

World Watch in the November/December 2008 issue contained a mistake. NASA occupies only 0.7 percent (not 7 percent) of the U.S. federal budget.

—Editor

A New Year of Discovery!

"Dusters" Stardust@home T-Shirt

Show that you're part of the Stardust@home team of volunteer investigators with our exclusive Dusters shirt. In 2006, the *Stardust* spacecraft captured the first particles from distant stars and brought them back to Earth. But before scientists can study these precious samples from faraway Suns, they will first have to find them. Stardust@home turned to tens of thousands of "dusters" who have been volunteering time and energy searching for evidence of these tiny pieces of star stuff. Are you a duster? Do you want to be? We have more online at *planetary.org/stardustathome/*.

Adult sizes: S, M, L, XL, XXL 1 lb. **#585**
Regular price: $22.22 **Member price: $20.00**

SETI@home Mug

More than 5 million participants have contributed their time and computers to SETI@home, the largest distributed computing experiment ever undertaken. Our 11-ounce mug features a wrap-around image of the classic SETI@home screensaver. 2 lbs. **#550**
Regular price: $11.11 **Member price: $10.00**

Nebula Poster

This awe-inspiring image from NASA's orbital Spitzer Space Telescope shows a false-color infrared view of nebula RCW 49—a birthplace for many hundreds of new stars and likely many thousands of planets.This stunning poster features one of Carl Sagan's poignant statements: "If we crave some cosmic purpose, then let us find ourselves a worthy goal."
22" x 34" 1 lb. **#315**
Regular price: $15.00
Member price: $13.50

Pale Blue Dot Poster

12" x 30" 1 lb. **#326**
Regular price: $11.11 **Member price: $10.00**

Surf Titan T-Shirt

Adult sizes: S, M, L, XL, XXL 1 lb. **#593**
Regular price: $22.22 **Member price: $20.00**

Target Earth T-Shirt

Adult sizes: S, M, L, XL, XXL 1 lb. **#598**
Regular price: $22.17 **Member price: $19.95**

Spacecraft Science Kits

Each sold separately. 1 lb.
Regular price: $17.50 **Member price: $15.75**

#525 Hubble Space Telescope
#530 *Lunar Prospector*
#560 *Voyager*

An Explorer's Guide to Mars Poster

24" x 37" 1 lb. **#505**
Regular price: $16.95 **Member price: $15.25**

"Is Anybody Out There?" Poster

39" x 16" 1 lb. **#320**
Regular price: $15.00 **Member price: $13.50**

Set Sail for the Stars! Poster

22" x 34" 1 lb. **#571**
Regular price: $15.00 **Member price: $13.50**

"Is Anyone Out There?" T-Shirt

Adult sizes: S, M, L, XL, XXL 1 lb. **#586**
Regular price: $22.17 **Member price: $19.95**

Planetary Society Cap

1 lb. **#673**
Regular price: $15.00 **Member price: $13.50**

Planetary Society Key Ring Medallion

1 lb. **#677**
Regular price: $17.78 **Member price: $16.00**

Planetary Society Lapel Pin

1 lb. **#680**
Regular price: $3.33 **Member price: $3.00**

We're Saving Space for You! Bumper sticker

1 lb. **#695**
Regular price: $3.33 **Member price: $3.00**

LAST CHANCE!
Deep Space Mysteries: 2009 Wall Calendar

Each month, enjoy awe-inspiring, full-color images from deep space. This 2009 wall calendar is produced by the creators of *Astronomy* magazine. 2 lbs. **#520**
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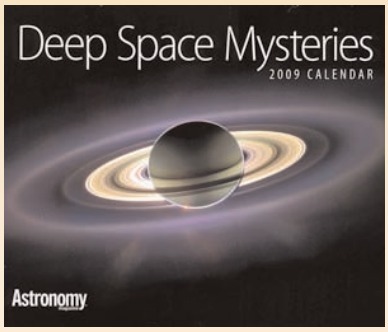

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In *Valles Umbrarum*, John Brosio shows how the kilometer-scale dust devils observed from orbit might appear from the surface of Mars. Scientists estimate that in Mars' thin atmosphere, solar warming of the suspended dust particles causes a temperature rise about two orders of magnitude larger than that inside terrestrial dust devils with similar particle concentrations. The resulting buoyancy increase may provide one explanation for the enormous size reached by these atmospheric vortices on the Red Planet. In 2005, Steve Fuesternau commissioned this painting to illustrate research on Martian dust devils he was doing for the Jet Propulsion Laboratory.

John Brosio is a member of The Planetary Society and an avid storm chaser. Many of his paintings depict the tornadoes that tear through the skies of the midwestern United States. He lives and works in Southern California.