The PLANETARY REPORT

Volume XXIII Number 4 July/August 2003

The Journey Begins

A PUBLICATION OF THE PLANETARY SOCIETY

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From The Editor

It's not often you can look at a span of time—a season—and know that it will truly mark a turning point in human endeavor. This summer is one such turning point. The *Columbia* Accident Investigation Board (CAIB) will issue its recommendations for future human spaceflight.

The CAIB report will alter the world's largest space agency and change the way humans get into space. The process will not be easy. Any entity as large and powerful as NASA does not alter course with alacrity. But with change comes opportunity. As you'll read in this issue, The Planetary Society, with other space interest leaders, has taken action to shape future spaceflight.

Meanwhile, an unprecedented fleet of spacecraft is on its way to the next human destination in space—Mars. To increase support for space exploration, the Society is working to involve everyone in this adventure. Our Red Rover Goes to Mars project is riding with the *Mars Exploration Rovers*. Mars Watch aims to get at least half of this planet's population to look at the Red Planet this summer. And Planetfest '04, the world's largest celebration of planetary exploration, is on its way. We hope that by next winter, nearly everyone on Earth will in some way have been touched by this ambitious and uplifting endeavor of humanity.

—*Charlene M. Anderson*

On the Cover:

On June 10, 2003, *Spirit*, the first of NASA's *Mars Exploration Rovers*, left Earth for its seven-month journey to Mars. These still images were extracted from live video returned by the RocketCam™ onboard imaging systems attached to the Delta II launch vehicle.

Images: Courtesy Rex Ridenoure, Ecliptic Enterprises

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Members' Dialogue

Planetary Radio

I've just noticed the ad for the Planetary Radio show in the latest issue of *The Planetary Report*. I'd like to hear that program in my area, so I have an idea: why not suggest (in the next issue of the magazine) that Society members write their local public radio stations to ask for that show to be carried at a good air time?

This would increase the number of listeners for the show and might help raise the number of Planetary Society members and donations.

—MICHAEL KELLY,
Lowell, Massachusetts

I hope every member follows your suggestion. In the meantime, you can hear Planetary Radio (as well as archived past shows) on our website, planetary.org.
—Charlene M. Anderson, Director of Publications

Mars Infrared

The "Mars Infrared" article in the May/June 2003 issue of *The Planetary Report* made fascinating reading. I am studying to be an astronomer, but my specialization isn't planetary astronomy, so it is always exciting to read articles and papers of the highest quality in subfields of my own. Could you publish more articles on extrasolar planets in your future editions?

It is a great honor for me and all Planetary Society members that our names fly on the *Mars Exploration Rover* and *Cosmos 1* missions. Thank you very much, and keep up the good work!

—INDRANEIL BISWAS
Ann Arbor, Michigan

Too Much Mars

Today I received the May/June 2003 issue of *The Planetary Report*. As with so many past issues, this edition is dedicated nearly in full to the exploration of Mars. In fact, the first 17 pages of a 22-page issue are devoted to Mars. Pages 18 and 19 are advertising, leaving 3 pages to discuss all other solar and extrasolar system subjects.

Nearly every e-mail update I receive from the Society is also concerned with Mars. I agree with all the important aspects of learning about Mars, such as whether liquid water ever flowed there, and whether life developed there. I also agree with the fact that now is a primary opportunity to explore Mars due to its close pass. It will be a future home of humankind.

While we may indeed find proof of past life on Mars, we are appropriating far too little energy to Europa. Indeed, you have devoted attention to Europa, but if our goal is to not only explore but discover life elsewhere, then a wider focus is in order.

Let's learn about Mars. It is very important to do so. But it is not all there is. I understand we have much more technology to develop to get to Europa, and it's much harder to get to. But that hasn't stopped us in the past, and it will not now.

The Planetary Society needs to be a leading voice toward these greater goals. That voice must speak more languages than "Mars."

—STEVE RICCO
Deerfield Beach, Florida

Many of the world's space agencies are focused on Mars this year particularly because of its closest approach in more than 50,000 years, and the fact that soon there will be seven spacecraft there. So, in terms of new results and active missions, a lot of what is going on now involves Mars, which is reflected in The Planetary Report *and in our e-mail updates. The Society is also a very active participant in the* Mars Exploration Rover *mission.*

Rest assured that the Society continues its broad support of planetary exploration and the search for extraterrestrial intelligence. This is evidenced by our recent political victory in restoring the Pluto mission, and our support for NASA's newly conceived Jupiter Icy Moons Orbiter. *And let's not forget our solar sail mission, and our very active near Earth objects, extrasolar planets, and SETI projects.*
—Bruce Betts, Director of Projects

Errata:

Due to a printing error in the May/June 2003 issue, text was lost from two sentences (at the end of page 13 and the beginning of page 14) in "Mars Infrared." The sentences should have read: "These instruments allow us—if we only get to look at the rocks—to at least look at them in as many wavelengths as possible. As designer and principal investigator of the Thermal . . ."

To read the article in its entirety, go to: *planetary.org/news/mars_infrared.html*

Also, the caption on page 7 stated that the Thermal Emission Imaging System rides on board *Mars Global Surveyor*. It is on *Mars Odyssey*.

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or e-mail:
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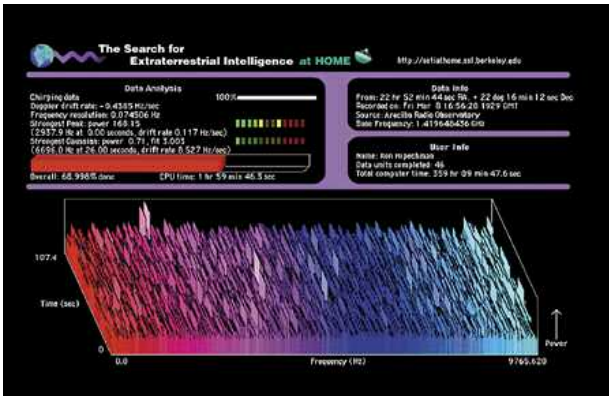
We Make It Happen!

by Bruce Betts

This issue contains updates on an amazing success and an amazing discovery: SETI@home continues on, yielding its first set of reobservations, and the recovery of a Planetary Society–sponsored experiment that was on board the space shuttle *Columbia*'s last flight.



SETI@home

The Planetary Society is the founding sponsor of the tremendously successful SETI@home project. When computer scientist David Anderson and SETI scientist/radio astronomer Dan Wertheimer came to the Society five years ago with an idea and a plea for money, even the most optimistic could not have foreseen where their idea would go. Fortunately, members made it possible for the Society to step in with seed money for the project, and the rest is history—well, evolving history. The Society's low-bureaucracy flexibility to make quick decisions that has yielded some of our most interesting projects. Many grant-funding foundations, and certainly government agencies, lack this agility that our members make possible.

In SETI@home, people download a screen saver for their personal computers that, when the individual computer is not otherwise occupied, chews on radio data from the 300-meter radio dish in Arecibo, Puerto Rico. The screen saver spits the processed information back to the central SETI@home computers at the University of California, Berkeley. Thus, SETI@home addresses one of the fundamental problems in radio SETI searches: lots of sky and lots of radio frequencies where signals from an extraterrestrial civilization could hide. Doing a good job of searching requires huge amounts of computer power.

From an ingenious idea and some seed money, SETI@home has become the largest distributed computing experiment in the world. Its success in attracting people is almost unbelievable: more than 4 million users! Some passively lend their idle computer time to SETI, others actively track—nay, compete —to see how much computer processing time and power they can contribute as individuals or as groups. A whole SETI@home culture has sprung up.

Thus, the world's largest computer (the distributed computing network) processing data from the world's largest radio dish is perhaps the perfect match of big-scale systems.

After lots of data, and lots of processing, we have just recently passed a big milestone in the SETI@home project: the first reobservations of the most promising candidate signals detected so far. In the four years since its launch, SETI@home has detected more than 5 billion (!) unusual

***This photo shows the box that contained the GOBBSS experiment, before opening, as it appeared after recovery in the debris field from the crash of the space shuttle* Columbia.**

Right: GOBBSS recovery team members Valerie Cassanto of Instrumentation Technology Associates (ITA), who provided the CIBX (Commercial ITA Biomedical Experiment) payload to the shuttle, and David Warmflash of NASA Johnson Space Center study sample containers after their removal from the experiment container. ***Photos: Louis D. Friedman***

events that potentially are signals from the stars. SETI@home scientists, using sophisticated criteria, then narrowed this to a short-list of the "best" 200 candidate signals, the ones most likely to come from an extraterrestrial civilization. One key test in SETI is to find repeated signals, which would argue that the first wasn't a fluke. This requires reobservation.

In March 2003, 166 celestial locations were reobserved. Early examination of the data showed no signs of intelligent signals, but the data must be processed further to rule out the possibilities. That will involve another SETI@-home groundbreaker, the first reobservation data going back out to participants for processing.

The pioneering efforts of SETI@home in successful distributed computing are now leading others to get into the game, looking for cures for cancer and understanding our bodies' building blocks, all with the help of distributed computing. The SETI@home software itself is being modified to be easily adapted to other applications.

SETI will always be a needle in a haystack process, but that needle would be humankind's most profound discovery. Thanks to support from Planetary Society members, we're searching millions of pieces of straw at a time.

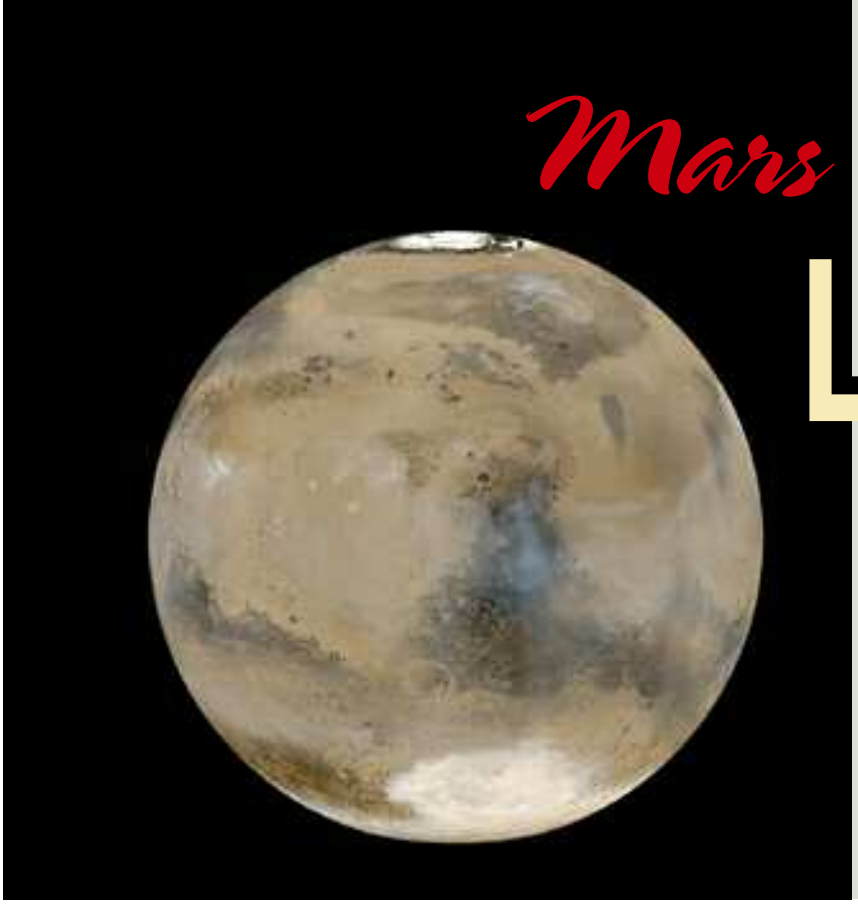
Columbia Experiment Recovered

The Planetary Society recently supported a space shuttle experiment for the first time. Unfortunately, it was on the tragically fated last flight of *Columbia*. In early May, amazingly, the experiment was removed successfully from its holding box, which had been found early on in the debris field. It appears still to be viable and will yield scientific information.

The Society's Growth of Bacterial Biofilm on Surfaces during Spaceflight (GOBBSS) experiment studies the viability of life surviving the rigors of space, with relevance to understanding whether life could survive on meteoroids blasted off one world and landing on another (e.g., Mars to Earth), so-called transpermia. GOBBSS's other goal is to encourage international cooperation in space: a Palestinian and an Israeli student selected via competition have been working together, and will continue to do so, on this experiment. For more information, see the March/April 2003 issue of *The Planetary Report* and *www.planetary.org/gobbss/index.html*.

Bruce Betts is director of projects for The Planetary Society.

Mars LOOMS LARGE



This view of the Red Planet is a composite of 24 global images acquired by Mars Global Surveyor*'s Mars Orbiter Camera on February 14, 2003.* *Image: JPL/NASA/MSSS*

by Bruce Betts

On August 27, 2003, Mars and Earth will be closer than they have been in more than 50,000 years. This proximity offers a rare opportunity to observe Mars, an opportunity met by a suite of five spacecraft headed for the Red Planet. Mars' close approach also gives you a great chance to see Mars yourself, either just by looking up in the sky or by attending one or more of The Planetary Society's Mars Watch and Mars Day activities.

Launch, Launch, Launch

Three successful launches have propelled a new fleet of spacecraft to the Red Planet. The onslaught began with the European Space Agency's *Mars Express* mission, which launched from Baikonur, Kazakhstan on June 2, 2003 on board a Russian Soyuz-Fregat rocket. *Mars Express*, the first European-led venture to Mars, consists of an orbiter and the British-built *Beagle 2* lander.

The *Mars Express* orbiter has a broad scientific agenda and will study Mars' subsurface, surface mineralogy, climate, and upper atmospheric interactions with space. The *Beagle 2* is an immobile lander that will study various questions related to climate and geology and will search for possible past or even present life on Mars. Dozens of scientists from 20 countries are involved with the *Mars Express* mission. *Mars Express*, including the *Beagle 2* lander, will encounter Mars around December 25, 2003.

The US entries in the 2003 Mars push are the *Mars Exploration Rovers* (*MER*s). These two spacecraft were launched successfully—*Spirit* on June 10, 2003 and *Opportunity* on July 7, 2003 from Cape Canaveral, Florida on Boeing Delta II rockets. The *MER*s will act as robotic geologists as they help us explore the surface

On June 10, 2003, **MER-A,** *containing the* **Spirit** *rover, blasted off to Mars on board a Delta II rocket. One month later, on July 7,* **MER-B** *launched, carrying the* **Opportunity** *rover.* **Spirit** *is set to land on January 4 and* **Opportunity** *on January 25, 2004.*
Photo: NASA

On May 8, 2003, the **Mars Global Surveyor** *(***MGS***) pointed its Mars Orbiter Camera (MOC) toward the Earth and took a picture. From a distance of 139 million kilometers (86 million miles), the Earth appears as a fuzzy blue disk, yet clear enough to show the outlines of continents and oceans. The Moon appears as a small dark disk not far from the Earth.*
Image: JPL/NASA/MSSS

Launched in 1998, **Nozomi** *(Japanese for "hope") has been on a long road to Mars. Arrival was set for October 1999, but a failure of a thruster valve during an Earth swingby caused* **Nozomi** *to take a slower route. The spacecraft will now arrive at the Red Planet in January 2004.*
Image ©ISAS

Europe kicked off our return to Mars with the first of three summer launches to the Red Planet. On June 2, 2003, **Mars Express,** *including the* **Beagle 2** *lander, launched on board a Soyuz-Fregat rocket.* **Mars Express** *is the first European-led mission to Mars.*
Photo: ESA

of Mars. Each will be able to travel up to 100 meters per day (compared to *Mars Pathfinder*'s *Sojourner* rover, which traveled less than 100 meters in almost three months). The rovers are about the size of golf carts, and each contains a suite of instruments to collect images and study the mineralogy and chemistry of the surface, including a set of instruments on a robotic arm. The *MER* mission involves dozens of scientists from many countries. *Spirit* is scheduled to land on January 4 and *Opportunity* on January 25, 2004.

Another spacecraft has been making its way to Mars since 1998. The Japanese *Nozomi* spacecraft didn't have enough thrust to get to Mars as it was supposed to, but some clever orbital mechanics using the Earth's gravity for assistance will get it there along with the rest of the spacecraft near the end of 2003. *Nozomi* completed its last flyby of Earth on June 19, 2003 and is headed off with the pack. *Nozomi* is having various technical difficulties, however, so the state of its eventual health remains to be seen.

Don't forget that we already have two working spacecraft orbiting Mars: *Mars Global Surveyor* and *Mars*

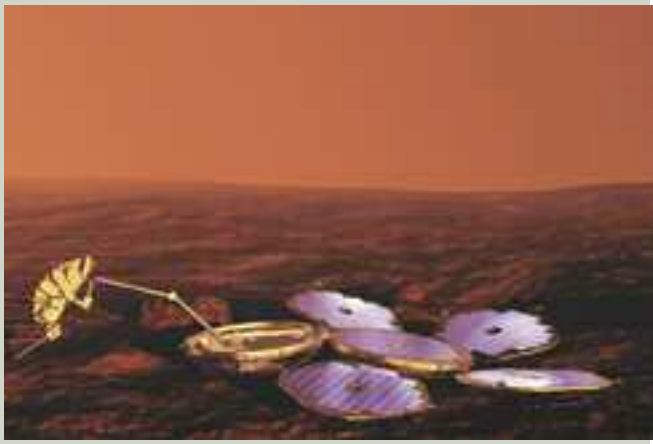
Author and Planetary Society Director of Projects Bruce Betts holds a replica of the Planetary Society–provided mini-DVDs that will fly on board each of the Mars Exploration Rover *spacecraft. Each assembly includes an Astrobot in the center, and each mini-DVD contains the names of more than 4 million Mars enthusiasts.*

Photo: Thomas Reil

Name the Rovers contest winner—9-year-old Sofi Collis from Scottsdale, Arizona—poses with a replica of a Mars Exploration Rover. *Sofi won the opportunity to name the rovers through a contest run by the LEGO Company and The Planetary Society for NASA.*

Photo: JPL/NASA

The European Space Agency's Mars Express *spacecraft will release the 30-kilogram* Beagle 2 *lander for a December 25, 2003 landing on the Martian surface.* *Painting: ESA*



Odyssey, both returning incredible data as they map the planet in various wavelengths. So, when we total up all the spacecraft that will be there by January 2004, the answer is seven, the largest concentration of spacecraft exploring Mars in human history.

To learn more about all the missions discussed here and those currently at Mars, visit The Planetary Society's new Exploring Mars website at *planetary.org/mars*. The site contains details about the missions, images of Mars, and personal accounts of some launches.

Naming the Rovers

Shortly before the launch of the first *MER* spacecraft, NASA announced the winner of a contest to name the *Mars Exploration Rovers*. Nine-year-old Sofi Collis from Arizona submitted the winning essay, in which she suggested *Spirit* and *Opportunity*. The LEGO Company ran the naming contest in partnership with The Planetary Society. More than 10,000 students in grades K–12 entered the contest. An esteemed group of judges gathered by the Society whittled the final entries down to 33, which then were submitted to NASA, which made the final selection. For more information, visit *redrovergoestomars.org/nametherovers.html*.

The Planetary Society Heading to Mars

With the successful launches of the two *MER* spacecraft, Planetary Society hardware is on its way to Mars, and a broader Society project moves into high gear. As discussed in more detail in last issue's "We Make It Happen!" (see the May/June 2003 issue of *The Planetary Report*), The Planetary Society's Red Rover Goes to Mars project is an official part of the *MER* mission. The Society provided mini-DVDs attached to the *MER*s that contain the names of nearly 4 million Mars enthusiasts, including all Planetary Society members. On the DVD mounting assemblies are the first Astrobots in space (see sidebar on page 9). After the rovers land, Society-selected international students will be stationed inside mission operations at NASA's Jet Propulsion Laboratory, actively participating in the surface operations of the mission.

Sizing up the Opposition

It isn't coincidental that the skies are being filled with Mars spacecraft as Mars and the Earth approach each other. The year 2003 offers great launch opportunities precisely because Mars is coming so close. Regular launch opportunities, when spacecraft can use the least amount of energy to get to Mars, occur every 26 months. However, because Mars' orbit is much more eccentric (noncircular) than Earth's, the distance between Mars and Earth during each close approach varies considerably.

At opposition, Mars is on the opposite side of the Earth from the Sun. Mars' perihelion occurs when it reaches the closest point in its orbit to the Sun. This year there is a perihelic opposition; that is, we come closest to Mars at the same time it comes closest to the Sun, and therefore to us.

Although the upcoming approach truly is the closest Earth has been to Mars in more than 50,000 years (once in a species), it has come nearly as close every few decades (once in a lifetime). At this opposition, Mars will be about 56 million kilometers (35 million miles) from Earth. At the next opposition, in 2005, Mars will be 70 million kilometers (43 million miles) away. The next time Mars will be closer than the 2003 opposition will be in 2287.

Mars Watch, Mars Day, and Beyond

Spacecraft are on the way to Mars, as is The Planetary Society, but don't forget to do your part: go outside, look up, and observe our ruddy neighbor. By mid-July, Mars will rise in the east around 11 p.m. At the time of opposi-

tion, at the end of August, it will rise roughly at sunset. Mars will appear much brighter than any star in the sky during the opposition period (magnitude –2.9 at opposition for those playing the home astronomy game). It also will have its characteristic red-orange color.

To encourage as many people as possible to look at Mars and get excited about the fleet of spacecraft ready to explore the planet, The Planetary Society is cosponsoring worldwide events to raise public awareness—a campaign we're calling Mars Watch. More than 100 such events in 50 locales are already being planned, with more scheduled each week. For details on observing Mars from your location or finding a Mars Watch event, check the Mars Watch site at *planetary.org/marswatch2003*. This site is full of information about the Red Planet. You can also hear weekly updates on Mars' approach on Planetary Radio at *www.planetary.org/audio/planetaryradio.html*.

In another effort to engage the public in this historic event, The Planetary Society will celebrate August 27 as "Mars Day" and encourage the world to do the same. Mars Day will serve as a focus for Mars Watch. In addition, that week, The Planetary Society will honor the 83rd birthday of Ray Bradbury, author of the famous *Martian Chronicles*. We are collecting birthday wishes for him on the Mars Watch website.

When these spacecraft reach the end of their journeys at Mars, The Planetary Society will celebrate Planetfest '04 at the Pasadena Convention Center on January 2–4. The event will include webcasts to the world. Planetfest '04 will correspond to the landing of the *Spirit* rover as well as to the fly-through of a comet by the *Stardust* spacecraft. We will also check in with *Mars Express* and *Beagle 2*, which will have arrived.

Don't miss the historic chances to see Mars and participate in Mars exploration. The next few months will be exciting. Let's get Martian!

Bruce Betts is director of projects for The Planetary Society.

Useful Links

Exploring Mars:
http://planetary.org/mars
Mars Watch and Mars Day:
http://planetary.org/marswatch2003
Red Rover Goes to Mars project:
http://redrovergoestomars.org
Astrobot Diaries:
http://redrovergoestomars.org/astrobots
Drive a Rover:
http://redrovergoestomars.org/drive.html
Planetfest '04:
http://www.planetary.org/planetfest04

The Astrobot Diaries

The first Astrobots in space were launched with the *Mars Exploration Rover* spacecraft. The Astrobots are LEGO mini-figure representations suited up for space. Biff Starling and Sandy Moondust, part of The Planetary Society Astrobot Corps, were launched on *Spirit* and *Opportunity*, respectively. (Biff and Sandy were named by Cindy Rosetto of Oregon. Hers was one of more than 1,100 entries to a Name the Astrobots contest run by The Planetary Society.) Each Astrobot is bolted to The Planetary Society– provided mini-DVD assembly that carries 4 million names of Mars enthusiasts to the surface of Mars.

Biff and Sandy's jobs are to tell the stories of their adventure to kids and the general public through fun, entertaining correspondence packed with information about the mission and Mars. These Astrobot Diaries can be found, along with more information, at *redrovergoestomars.org/astrobots*. You can also hear Biff and Sandy on Planetary Radio from that same link.

Biff Starling is a last-minute replacement Astrobot, selected to step in after a freak zucchini accident took one of the original Astrobots out of the running. Biff is a laid-back wannabe leisure-bot who speaks fluent surfer. During his launch, Biff was quoted as saying, "Whoooooaaaa!" and "Aaaahhhh, here it goes again, I'm feeling squished, and not in a good way."

Sandy is living her dream. She is prone to seriousness and has a wealth of knowledge about the mission. Her favorite color is beige, and the only thing she might rather be doing is correcting grammar. During her launch, she was quoted as saying, "The accelerations are as expected. I am honored to have this opportunity." *—BB*

***Astrobots Biff Starling (left) and Sandy Moondust, the first Astrobots in space, are on their way to Mars. Read about their adventures at* redrovergoestomars.org/astrobots.**

Image: Emily Stewart Lakdawalla

Before Astrobot Sandy Moondust began her journey to Mars, she spent some time visiting Kennedy Space Center in Cape Canaveral, Florida.

Photo: Susan Lendroth

World Watch

by Louis D. Friedman

Earth—The eyes of the world are turning toward Mars. The European orbiter, *Mars Express*, carrying the lander *Beagle 2*, and NASA's twin rovers, *Spirit* and *Opportunity*, are all on their way to Mars. Their launches were exciting and dramatic events, but now comes the really hard part—getting to and landing on Mars in good condition. In the last decade, *Mars Observer*, *Mars 96*, *Mars Climate Orbiter*, *Mars Polar Lander*, and *Deep Space 2* did not make it to their destination. But *Mars Pathfinder* (carrying the rover *Sojourner*), *Mars Global Surveyor*, and *Mars Odyssey* reached their goal. In recent years, we're 4 for 10 at Mars.

Japan's *Nozomi* is also on the way to Mars. It was launched in 1998 and has had a fitful journey. During an Earth swingby in December 1998, an errant propulsion maneuver prevented the spacecraft from following the planned trajectory to reach the Red Planet in 1999. But Japanese mission engineers cleverly found a trajectory with two more Earth swingbys that enabled an encounter in December 2003.

However, while on this trajectory, the spacecraft apparently was hit by particles from a large solar flare near the maximum of the solar cycle, damaging its power and communications systems. Mission controllers will try to work around these difficulties, but it is not clear how much data they will be able to recover. They are still hopeful they will be able to guide the spacecraft into Martian orbit in December. *Nozomi* means "hope" in Japanese, and we hope the spacecraft is aptly named.

Washington, DC—At this time of the year, we are usually reporting on the progress of the NASA budget as it wends its way through Congress. So far, there is little progress to report. The budget that President George W. Bush submitted last February contained several new exploration initiatives and provided substantial support for planetary missions (see "World Watch" in the March/April 2003 issue of *The Planetary Report*). Following the loss of *Columbia* and her crew, however, Congress and the Bush administration must face huge policy issues, and those have dwarfed the budget consideration.

The congressional committees responsible for NASA are not expected to act on the budget until fall. They are awaiting the report of the *Columbia* Accident Investigation Board and whatever budget request might be made as a result. The fixes to the shuttle and proposals for either its continuance or its replacement (or for both) are certain to have significant budget implications.

The shuttle fleet is grounded, yet the International Space Station and her crew must be supported. This has led to reliance on Russian launch and crew transfer capability, which has been accepted reluctantly by US policymakers.

The resulting policy issues include whether or not to upgrade the shuttle fleet after immediate repairs and modifications permit it to return to flight status. Some have suggested that these upgrades could extend the life of the shuttle beyond 2006 to perhaps 2020 or 2025. NASA has begun development work with contractors for an Orbital Space Plane (OSP)—a crew transfer vehicle whose original purpose was to bring astronauts home, in case of emergency, from the space station. It would have eliminated reliance on the aging Russian *Soyuz* capsule. Now NASA is considering making the OSP into a crew vehicle for flying to and from the station. In its final version, the OSP might not be a plane at all, but a capsule similar to the *Soyuz* or *Apollo* command capsules from an earlier generation.

The Planetary Society is involved in the debate (see page 17), not so much for our technical opinion on vehicle design but for our strong advocacy that the requirements for exploration beyond Earth orbit be dominant in considering what steps to take next in human space transportation.

Europe—Europe, too, had its launch vehicle problems. The Ariane 5, Europe's chief transport to space, suffered a failure late last year. One casualty was the *Rosetta* mission to rendezvous and land on a comet. Its launch had to be postponed until the problem with Ariane 5 could be diagnosed and repaired. This delay increased costs, and for a while there was some doubt that the member nations of the European Space Agency (ESA) would provide all the funds needed to support Ariane, the International Space Station, *Rosetta*, and its existing space science program.

Just prior to a meeting of European science ministers who control the budget for ESA, The Planetary Society lobbied in support of all these programs. The ministers agreed to support all these items, and *Rosetta* has been given a green light to set out for comet Churyumov-Gerasimenko next year. The spacecraft will be launched in February 2004 from Kourou, French Guiana to rendezvous with the comet in November 2014.

In mid-June, Ariane 5 successfully carried a cargo of telecommunications satellites to Earth orbit, and it looks like the European program is back on track.

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

Searching for Vulcan

by Daniel D. Durda

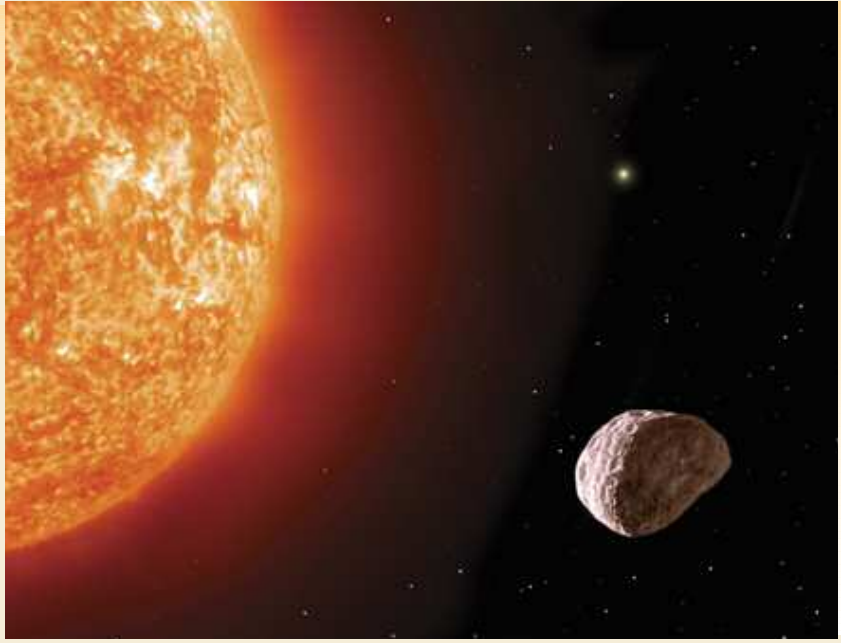
Just in front of me, the small LCD monitor glowed with a dim, blue-gray light, the display showing a sharply focused image of the star field on my checklist. I had most of the other displays in the rear cockpit of the F/A-18B Hornet turned down very dim so that the scattered light would not interfere with the images being recorded by the sensitive video camera mounted above the instrument panel. In the front cockpit, NASA pilot and former space shuttle commander Rick Searfoss flew us on a straight and level track at an altitude of 49,000 feet over the desert north of the Dryden Flight Research Center in California. Just a day earlier, my colleague and fellow flight astronomer Alan Stern flew the same flight profile, pointing our camera to the eastern sky above the narrow ribbon of early morning twilight, searching for "the vulcanoids."

Our elusive quarry are not diminutive relatives of Mr. Spock but in fact a long-sought population of small asteroids that may orbit the Sun well inside the orbit of the planet Mercury.

The Inner Frontier of the Solar System

A hundred years ago, astronomers were having a hard time accounting for the rate of advance of the perihelion (the closest point to the Sun) of Mercury's orbit. Isaac Newton's law of universal gravitation had allowed celestial mechanicians to calculate the gravitational effects (perturbations) of the other planets on Mercury. One effect of these perturbations is to cause the long dimension of Mercury's fairly eccentric orbit to slowly rotate in space, so that each successive perihelion passage occurs in a slightly different direction with respect to the Sun. According to Newtonian gravitational theory, the

In the region between Mercury and the Sun, there may orbit a population of asteroids called vulcanoids. On April 16, 2003, a test flight to evaluate the conditions for a vulcanoid search from suborbital altitudes launched from the White Sands, New Mexico Missile Range. Photo: Daniel D. Durda



Vulcanoids, named for the Greek god of fire and metallurgy (rather than Mr. Spock's home planet), might contain samples of planet-building materials from the inner solar system's earliest history. Here, a lone vulcanoid orbits close to the Sun. The bright "star" in the background is the planet Mercury.

Painting: Daniel D. Durda

perihelion of Mercury should be advancing by a little less than 0.15 degree per century, but the actual observed advance was more like 0.16 degree per century.

One solution to the discrepancy postulated a small, undiscovered planet orbiting even closer to the Sun than Mercury. As the theory went, the undiscovered planet's hitherto unaccounted-for gravitational influence might account for Mercury's "extra" perihelion advance. A planet so near the Sun would be even hotter than Mercury, so the hypothetical planet was named Vulcan, after the Greek god of fire and metallurgy. After early searches turned up no obvious new planet, some suggested that perhaps a massive ring of smaller, "vulcanoid" objects might also do the trick.

As it turned out, the wind was taken from the sails of early Vulcan and vulcanoid searches in 1916, when Albert Einstein published his general theory of relativity. According to general relativity, the energy and momentum of a moving body contribute to its effective mass, and thus to the force of gravitation acting on it. Because Mercury moves fastest in its rather eccentric orbit when it is at perihelion, general relativity predicts that all the motional and gravitational effects add to the attraction between Mercury and the Sun, providing a very tiny additional push on Mercury over and above that predicted by Newtonian gravity. This additional push nicely explained the extra 0.01 degree per century in Mercury's perihelion advance. The astronomical "necessity" for a planet Vulcan or a massive belt of vulcanoids had disappeared.

Curiosity nevertheless remained concerning the possibility of an as-yet-undiscovered population of asteroid-like objects orbiting in the inner frontier of the solar system. Over the past few decades, our understanding of the solar system has grown dramatically as a series of populations of small bodies, until recently wholly or largely undetected, have been revealed in increasing detail by modern observing techniques. These populations include the near-Earth asteroids, the Centaurs orbiting in the giant planet region, and the Kuiper belt objects beyond Neptune. In each case, these new populations of objects were first detected years after astronomers suggested they could exist. Among the few dynamically stable niches in the solar system that today remain largely unexplored is the region interior to Mercury's orbit, the realm of the hypothesized vulcanoids.

A Century-Old Search

This putative reservoir of small, asteroid-like objects is of interest to planetary scientists because it could contain a sample of planet-building material left over from the earliest days of the inner solar system. Because of the intense thermal conditions and comparatively harsh collisional environment characteristic of this region, a popula-

Above: The F/A-18B Hornet in flight—an unusual and fun way to do planetary science. *Photo: Lori Losey*

Right: The Southwest Ultraviolet Imaging System-Airborne (SWUIS-A) camera installed in the rear cockpit of the plane. *Photo: Tony Landis*

tion of vulcanoids might be expected to contain unique mineral assemblages not seen in other populations of small bodies like asteroids and comets farther from the Sun. (Impact speeds between vulcanoids are greater than those between asteroids in the main asteroid belt because orbital speeds are higher as objects get closer to the Sun, and nongravitational forces due to sunlight that affect the motions of small bodies are very much greater so close to the Sun.) Because a population of vulcanoids would impact and crater Mercury but almost no other body in the solar system, knowledge of just how many vulcanoids may exist would aid our understanding of that planet's surface chronology and impact history.

Dedicated to the SEARCH

Many highly skilled and very dedicated people at NASA's Dryden Flight Research Center made our 2001–2002 high-altitude search for vulcanoids possible. I cannot say enough good words about our lead pilot and project coordinator, Rick Searfoss, who made it all come together. Bob McElwain, Ray Kinney, Nick Kiriokos, and Jeff Greulich in the Life Support Branch kept us safe and made sure our personal flight gear and survival and recovery systems were in fine working order. Our ground and aircraft crew—Rod Nida, Rocky Radcliff, De Garcia, Kevin Mount, and Dan Batcho—skillfully integrated SWUIS-A into the aircraft and kept us flying. Some of the best pilots in the world put us on target, on time to gather our data: Rick Searfoss, Frank Batteas, Dana Purifoy, and Craig Bomben. Thanks, guys! —*DDD*

Theoretical models constructed by myself and Alan Stern indicate that a modest population of a few hundred kilometer-size and larger vulcanoids could have survived the harsh collisional and dynamical environment in this region of the solar system from primordial times to the present day. Unfortunately, although a modest population of vulcanoids may well exist and have significant value to planetary science, they are exceedingly difficult to observe from the ground because they orbit so near the Sun. Anyone who has looked for the planet Mercury in the morning or evening twilight can attest to the comparative difficulty of observing that planet versus naked-eye viewing of the other planets. Any vulcanoids would be much smaller and fainter than Mercury, and would appear very low on the horizon, even nearer to the Sun against an even brighter twilight sky. It's a tough observational nut to crack!

Most previous ground-based observations to search for vulcanoids have been made during total solar eclipses and during the brief twilight period very shortly after sunset, before the vulcanoids themselves set, or just before sunrise, after the vulcanoids have peeked above the horizon. These snapshot searches were limited to a comparatively bright limiting visual magnitude of 8.5 (the brightest stars in the sky are at magnitude 0 and the faintest stars visible to the unaided eye are at about magnitude 6), corresponding to objects with diameters larger than about 30 km, much larger than any vulcanoids we expect would exist. Other proof-of-concept observations in the near-infrared portion of the spectrum took advantage of darker skies at those wavelengths and of the fact that hot vulcanoids are brightest in that portion of the spectrum. However, those observations also did not find any vulcanoids.

In 1999 and 2000, my colleagues and I at the Southwest Research Institute's Department of Space Studies in Boulder, Colorado used images recorded in space by the Solar and Heliospheric Observer (SOHO) spacecraft to beat the twilight problem and conduct a new search for vulcanoids. SOHO's Large Angle and Spectrometric COronograph (LASCO) is used by solar astronomers to

The author, suited up, in the air, and on the trail of big vulcanoid game. Photo: Daniel D. Durda

Colleagues and fellow flight researchers, Alan Stern and Dan Durda (right), pose in front of one of NASA's F/A-18B Hornet aircraft. The SWUIS-A camera is visible in the rear cockpit of the plane. Photo: Mike Smith

study the Sun's million-degree corona, but the instrument also sees background stars, the planets when they pass near the Sun in the sky, and occasionally Sun-grazing comets on their swan dives to oblivion. It occurred to us that this instrument might be used to search the region inside Mercury's orbit for vulcanoids. Although in the end we detected no vulcanoids (it turns out that LASCO, which wasn't designed to observe faint, star-like objects, could see moving objects only down to a magnitude of 8, about the same as that reached by the best ground-based searches), we did significantly improve on past work by searching the entire vulcanoid region.

A New Search Takes Flight

In 1998, when I first joined the Southwest Research Institute, Alan Stern was working to develop a versatile and capable low-cost astronomical imaging system that could be flown aboard small, high-performance jet aircraft—a sort of faster, cheaper version of NASA's former Kuiper Airborne Observatory or the upcoming SOFIA (Stratospheric Observatory for Infrared Astronomy). The idea was to develop and demonstrate the capability to routinely and comparatively inexpensively observe rare and/or high-priority astronomical events, such as planetary occultations, where conventional ground-based observers may not be able to either because of bad weather or because the events were observable only over the oceans. Alan and his close collaborator Dave Slater successfully adapted his SWUIS (Southwest Ultraviolet Imaging System) instrument—which flew aboard the space shuttle on STS-85 and STS-93 to gather unique ultraviolet imaging data on comet Hale-Bopp, the Moon, and Jupiter—for flights aboard NASA WB-57 and F/A-18B aircraft.

The new instrument was called SWUIS-A, for SWUIS-Airborne. I began working with Alan to demonstrate the capabilities of the new system in a series of research flights out of NASA's Dryden Flight Research Center at Edwards Air Force Base in California. SWUIS-A consists of a very sensitive, image-intensified CCD (charge-coupled device) camera that covers a broad range of visible and near-infrared wavelengths; high-quality lenses; a small video recorder; an aircraft-to-camera power and telemetry box with camera controls (we call it the PIB, which stands for power interface box); a Global Positioning System (GPS) time video encoder unit; and associated cables, filters, and other minor equipment. Mounted inside the aircraft, SWUIS-A's camera records images at video rates (60 images every second), which gives us the high time resolution needed for research such as occultation studies and allows us to compensate for image drift and jitter caused by the motion of the aircraft.

Flying with SWUIS-A in the rear cockpit of a two-seater F/A-18B Hornet aircraft that NASA uses for photo chase missions (a NASA research pilot in the front cockpit flies the aircraft), Alan and I honed the process of mission planning, instrument pointing, and data processing during a series of flights to observe asteroid occultations. By the successful conclusion of that flight

Evening Twilight Flights SPRING 2002

MARCH 28
Pilot: Rick Searfoss, SWUIS-A flight astronomer: Dan Durda

APRIL 1
Pilot: Dana Purifoy, SWUIS-A flight astronomer: Alan Stern

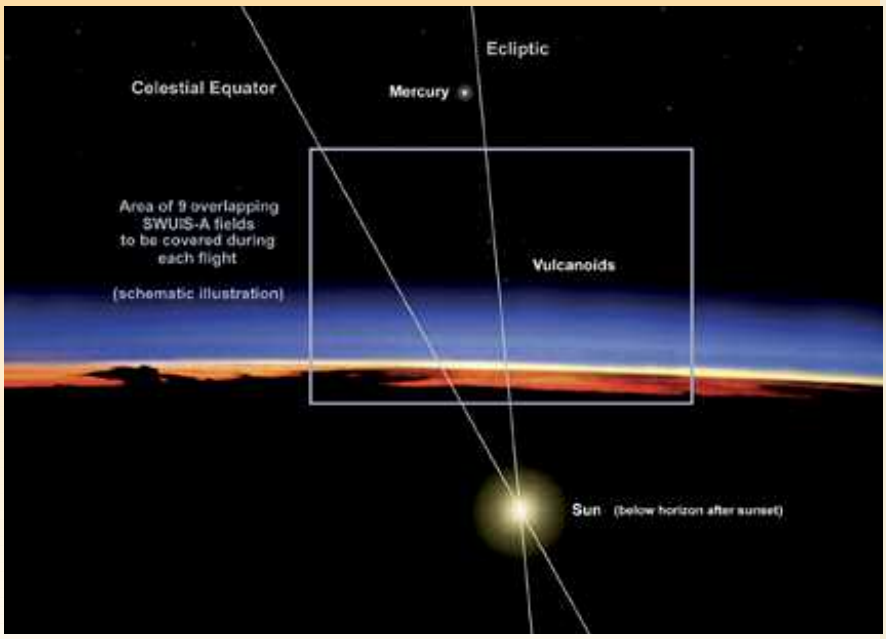
APRIL 2
Pilot: Craig Bomben, SWUIS-A flight astronomer: Dan Durda

Morning Twilight Flights FALL 2002

SEPTEMBER 17
Pilot: Frank Batteas, SWUIS-A flight astronomer: Alan Stern

SEPTEMBER 19
Pilot: Craig Bomben, SWUIS-A flight astronomer: Alan Stern

SEPTEMBER 29
Pilot: Rick Searfoss, SWUIS-A flight astronomer: Dan Durda



This schematic illustration shows the geometry of a high-altitude vulcanoid search. Near the spring and autumn equinoxes, the ecliptic plane as seen from Earth can be almost vertical at sunrise or sunset with respect to the horizon. This places the vulcanoid zone as far as possible above the horizon. *Illustration: Daniel D. Durda*

demonstration program, we realized that the capabilities of SWUIS-A (among them, the ability to see objects as faint as magnitude 13 in a dark sky, corresponding to vulcanoids less than 10 km across) were well suited to a new search for vulcanoids. The high-performance F/A-18B aircraft we were flying had the ability to reach very high altitudes, high enough to observe from above much of the atmosphere and obtain far darker twilight conditions than is ever possible from the ground. From those altitudes, we might be able to beat the classic problems associated with the atmosphere that had plagued previous ground-based vulcanoid searches. With funding from NASA and the National Geographic Society, we set about our new mission.

Because we already knew SWUIS-A's performance characteristics and we would be flying in the same configuration as before in the NASA Hornet, I began by planning the best time to fly. During the several-day period near the first day of spring or autumn, the ecliptic (the plane of the solar system in which the planets and most other small bodies like vulcanoids orbit) can appear nearly vertical with respect to the horizon, as seen from the southern latitudes of the United States. The most favorable observing geometry occurs after sunset near the spring equinox and before sunrise near the autumn equinox. After a scrubbed mission in the wake of the terrorist attacks of September 11, 2001, Alan and I flew a total of six vulcanoids search flights in March and September 2002.

Imagine that your observatory is an F/A-18B Hornet cockpit at 49,000 feet in the predawn hours. The all-sky canopy offers an unobstructed view extending from the star-filled, inky black zenith above to the pure rainbow hues of twilight, compressed to a narrow band along the horizon. The instruments and system displays of one of the world's most advanced aircraft glow dimly in front of me as I monitor the data being recorded by the imaging system. A former space shuttle commander is harnessed in just a few feet in front of me, expertly flying on a precise heading through the near-space environment. All in all, it's a heck of an unusual observing run and a fun way to do astronomy!

The vulcanoids search images we recorded demonstrated the usefulness of our basic technique of flying high to reduce the brightness of the background twilight sky. From aboard the Hornet, we were indeed able to observe much fainter objects near the Sun than we would have had we operated SWUIS-A on the ground. However, our detection limit wasn't quite faint enough (therefore the twilight wasn't as dark as we wanted) to improve upon our previous SOHO search. The Hornet doesn't like flying much above 50,000 feet, and we would be required to wear at least a partial pressure suit above that altitude, so we couldn't fly any higher on those flights. We're on the right track, but we need to fly even higher to achieve an even darker twilight sky.

Aim High—Really High!

To that end, we are now exploring options to fly SWUIS-A aboard U-2 or MiG-25 aircraft to altitudes approaching 80,000 feet or more. Recently, we flew one of our sensitive cameras aboard a NASA sounding rocket (from the nautical term "to sound," which means to take measurements) as a proof of concept for vulcanoids searches at suborbital altitudes. The 58-foot-tall rocket flew to an altitude of nearly 900,000 feet (that's right—274 kilometers up!) from the White Sands Missile Range in New Mexico to test Alan's new ultraviolet imaging spectrograph. We flew VULCAM (basically the same as SWUIS-A, but without the PIB), the same imager we flew on the Hornet flights, as a piggyback payload. VULCAM operated perfectly in space, paving the way for future operational vulcanoids search flights at altitudes near those achieved by the space shuttles.

We're not giving up. If the vulcanoids are there, we're going to find them!

Daniel D. Durda is a planetary scientist at the Southwest Research Institute in Boulder, Colorado, where he studies collisional and dynamical evolution of asteroids and the effects of their impacts on Earth, as well as airborne astronomical observations from high-performance jet aircraft. A pilot, cave diver, author, and space artist, Durda is also the coordinator for the Society's Gene Shoemaker Near-Earth Object Grant Program.

Propelling Humans Beyond Earth Orbit

by Louis D. Friedman

After recovering from the first wave of sadness and shock at the loss of life with the space shuttle *Columbia*, we at The Planetary Society realized that two big issues now faced all those who support space exploration: what caused the accident, and what should be done next.

Investigating the cause of the accident is not in the province of The Planetary Society (although one of our directors, John Logsdon, is serving on the investigation board), but helping to determine what should be done next to resume space exploration is exactly what the Society should be doing. Our organization is the leading public advocate of human and robotic space exploration. The current space transportation infrastructure, conceived in the mid-1970s and based on the space shuttle, has confined the United States' human exploration program to Earth orbit. The shuttle, despite its technical success, sits like a jackknifed trailer on the highway to space.

The *Columbia* accident reduced the shuttle fleet to three, eliminating a quarter of the US capability. We knew

(continued on next page)

Apollo ***was the first—and last—project to launch human explorers to another world. The experiences of the 30-plus years since the last astronauts walked on the Moon have proved that it's not as easy as it once looked to transport people into interplanetary space. Here*** **Apollo 11** ***blasts off from Kennedy Space Center on July 16, 1969.*** ***Photo: NASA***

some would call for building a fourth orbiter. There was already strong support within NASA for extending the life of the shuttle program, perhaps for another two decades—extending our confinement to Earth orbit.

We decided that we had to take a leadership position in the post-*Columbia* debate about the future of human spaceflight. We did not intend that debate to focus simply on how to recover from the accident and resume business as usual. Nor did we want it to drift into fantasyland with dreams of orbiting hotels and millionaires' vacation trips making space available for "everyone." It is our strong opinion that government support for human spaceflight rests on public interest in exploration and discovery. The decisions soon to be made about the future of human space transportation should drive toward human exploration beyond Earth orbit.

The Planetary Society is the largest space interest group on Earth and essentially the only representative of public interest in space exploration. But public interest alone does not determine policy. We need allies directly involved in human spaceflight as well as allies within the space industry. We turned to two organizations who represent these constituencies. The Association of Space Explorers (ASE) is the organization of all those who have actually flown in space, both astronauts and cosmonauts. The American Astronautical Society is a professional society of aerospace engineers, scientists, and leaders who conduct the United States' space program. Together, the three organizations represent a broad spectrum of interest and expertise.

After a phone call to each, both organizations immediately joined with us. They too saw the need for a public debate about human space exploration. We decided first to organize a small, focused workshop of experts to flesh out and debate the issues. To help focus the debate, we commissioned several background papers on technical and international aspects of the subject. These, and the full set of conclusions, can be found on our website.

The Planetary Society and the American Astronautical Society officially adopted conclusions reached at the workshop, which we believe point the way to human exploration beyond Earth orbit and on to other worlds. Although all the astronauts at the workshop agreed with these conclusions, many of the other astronauts on the ASE-USA Board did not endorse the early retirement of the shuttle or the strong conclusion about separating crew and cargo. However, among the workshop participants, Skylab and shuttle/Spacelab astronaut Owen Garriott and four-time shuttle astronaut Thomas Jones joined with us as spokesmen for the statement and have agreed to join The Planetary Society's Advisory Council.

This is the strategy proposed by The Planetary Society and the American Astronautical Society:

- By adopting a phased approach to human exploration beyond Earth orbit, we can develop a cost-effective program that is exciting and scientifically rewarding, and for which the risks can be measured and managed.
- The initial stages of a robust human exploration architecture can proceed using existing and currently planned propulsion technologies.
- We see no essential role for continuing flight of the three remaining shuttle orbiters beyond their immediate goal of completing construction of the International Space Station and early transport of crew members to and from the station in the near term. As soon as an additional mode of human transport into and from low Earth orbit (LEO) is available, which should occur as soon as possible, the shuttle orbiters should be retired.
- Crew and cargo should be transported separately to increase flexibility, reduce vehicle turnaround time and cost, and reduce risk associated with human space exploration.
- The underutilized fleet of existing expendable launch vehicles should play a major role in the next stages of human space exploration, as well as in human and cargo transportation into LEO.
- Increased investment in on-orbit operations and in-space propulsion technologies is required.

These conclusions, including this strategy, have been sent to NASA Administrator Sean O'Keefe and to the chairs and ranking minority members of the congressional committees who authorize NASA's programs. They also have been publicized in the media and transmitted to the *Columbia* Accident

Together, We Make a Difference!

We thank members of The Planetary Society for their financial and grassroots support for this workshop and for all our efforts to promote space exploration, human and robotic. The projects and programs of the Society—technical adventures like the solar sail mission, educational endeavors such as Red Rover Goes to Mars, advocacy for the NASA Mars program and a Pluto mission, and this workshop on human space exploration—are all enabled by the voluntary donations of members.

We also thank Elon Musk of the Musk Foundation and the Kenneth T. and Eileen L. Norris Foundation for their support for this workshop. Their early commitment of funds permitted the Society to act quickly. *—LDF*

Investigation Board. How they will influence the decision about next steps in human space transportation remains to be determined over the next few months. We intend to stay active in that consideration.

Many open issues and difficult questions remain to be resolved, even if our statement were to be adopted as policy. There are debates about various competing technical designs for crew transport, whether reusable craft are cheaper or more expensive, the use of existing facilities and hardware, whether we should use more international capabilities, and whether interim steps are stepping-stones or stumbling blocks on the highway to space. If we succeed in establishing that the advancement of human space exploration beyond Earth orbit is the criterion for resolving the debates, then we will have succeeded.

We invite our members to review the full report on the workshop conclusions on our website: *planetary.org/workshop/*. We also invite you to use the website to contribute your own views. This discussion will not end soon, and we shall continue our advocacy, building on the mounting public interest in the future of human space exploration.

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

Above: Two of the most important scientific destinations for human explorers are the Moon and Mars. In this futuristic scene, a crew of lunar explorers prepares for the trip home by refilling their spacecraft's propellant tanks with oxygen produced on the Moon.

Illustration: John Frassanito and Associates for NASA

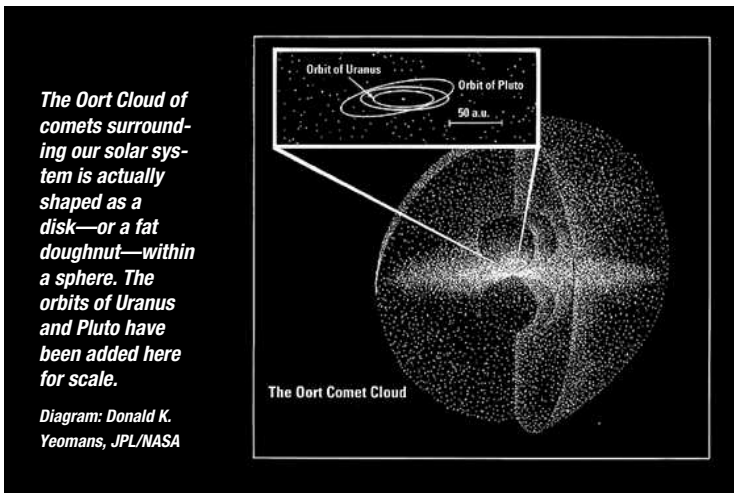
Left: Mars is the ultimate destination for human explorers in the foreseeable future. Consequently, the robotic Mars exploration program should progress beyond sample return to robotic outposts in preparation for human presence on the Red Planet. These steps will pave the way for scientists to work on Mars, piecing together its history and searching for evidence of ancient life.

Illustration: Pat Rawlings, SAIC, for NASA

Questions and Answers

Why is the Oort Cloud believed to be spherical in shape? Why wouldn't it be spread out into a disk in line with the plane of the solar system?
—V. Vinson,
La Crescenta, California

The young Oort Cloud probably did have a disklike shape, reflecting the outward scattering of planetesimals and other debris from the Sun's accretion disk. However, we know that the long-period comets fall into our solar system's planetary region in an essentially isotropic (equal in all directions) distribution, leading us to think that the cloud's initial disklike configuration must have been reshaped into a sphere.



The Oort Cloud of comets surrounding our solar system is actually shaped as a disk—or a fat doughnut—within a sphere. The orbits of Uranus and Pluto have been added here for scale.

Diagram: Donald K. Yeomans, JPL/NASA

This reshaping is due, most likely, to external perturbations of passing stars. Individually, these perturbations are small, but over time many of them take place. Because the directions from which stars approach the Sun are random, the cumulative effect of all these perturbations has been to randomize the orbits of the comets. That process may have taken about a billion years. By 1950, Dutch astronomer Jan Oort had most of this figured out, which is why his name is attached to the Oort Cloud.

However, this is not the whole story. The effect of passing stars on the Oort Cloud comets is largely dependent on the comets' distance from the Sun. The long-period comets, the ones that were the subject of Oort's analysis in 1950, come from the so-called outer Oort Cloud, with a characteristic radius near 50,000 to 100,000 astronomical units (one astronomical unit is equal to 150 million kilometers, or 93 million miles, the distance between Earth and the Sun). Objects at much smaller distances are more tightly bound to the Sun, so their orbits might not yet have been randomized by external perturbations. For this reason, the inner Oort Cloud is thought to be a flattened disk of comets (a fat doughnut would be a better description) that blends imperceptibly into the outer Oort Cloud at farther distances (see diagram).

—DAVID JEWITT,
University of Hawaii

What causes the different-colored bands in Saturn's and Jupiter's atmospheres? And why is Uranus' face so bland?
—Kirby Milner,
Kansas City, Missouri

Jupiter and Saturn are giant balls of rapidly rotating gases. Their atmospheres are heated from above by the Sun and from below by their internal heat sources. The internal heat causes powerful currents to rise through Jupiter's and Saturn's atmospheres. These currents can carry chemical compounds from the planets' interiors to higher—perhaps visible—levels.

Both of these planets' clouds are organized into latitudinal bands. These bands are disturbed occasionally by discrete features (storms) or turbulence, especially at transitions where the winds are changing direction. Traditionally, the lighter bands are called *zones* and the darker ones *belts*. Zones generally are regions of upwelling air capped by white ammonia cirrus clouds. Belts are thought to be regions where the cooler atmosphere moves downward, completing the convection cycle. Because there are fewer ammonia clouds there, belts are darker, which allows us to see deeper into the atmosphere. These bands can appear to shift in brightness, color, and position from year to year.

Slight variations in chemistry and temperature are responsible for the differences in the colored bands that dominate the appearances of Jupiter and Saturn. Sulfur and red phosphorus, as well as various photochemically produced organic compounds, have been suggested as *chromophores* (coloring agents) for the bands; however, no firm identifications of the chemicals involved have been made. Also, the bands' colors generally correlate with cloud altitude: blue is deepest, followed by browns and whites, and reds are highest. Sometimes holes in the upper layers allow us to see down to lower layers.

Neptune's and Uranus' atmospheres are also organized into latitudinal bands of varying color and brightness (in spite of Uranus' anomalously large axial tilt of 98 degrees). As with their larger planetary counterparts, a balance between internal heat and external solar flux is thought to play a role in creating Uranus' and Neptune's visible cloud structures. Uranus' cloud patterns are perhaps the most muted of any

giant planet's because its internal heat is very low, if not zero. Neptune, on the other hand, has the largest internal heat source of all the gas giants, as well as an extremely dynamic atmosphere.

A topic of great interest to Uranus observers is that the planet's radiation balance may be changing right now. Uranus, which had been oriented with its south pole toward the Sun for the past few decades, is now approaching an equinox, which will occur in 2007. At that time, both hemispheres will be equally illuminated. Planetary astronomers have begun monitoring Uranus at wavelengths that range from radio to ultraviolet in order to detect evidence of seasonal change in the planet's cloud cover. We won't have conclusive information for several years, but initial hints are that Uranus may undergo some very interesting changes. Stay tuned.

—HEIDI B. HAMMEL,
Space Science Institute

Factinos

An international team of astronomers has discovered seven extremely large circumstellar disks silhouetted against the forming stars that they surround (see image below). These new disks are 10 to 100 times as large as both our solar system and other planet-forming disks that have been imaged. The international team, led by Richard Elston and Elizabeth Lada of the University of Florida in Gainesville, presented its results at the May 2003 meeting of the American Astronomical Society.

The fact that these disks extend many times farther than comparable local disks suggests that planets could also extend well beyond the relatively close proximity observed in our solar system and others. "That would be good news for astronomers, because planets are notoriously difficult to detect near stars, which swamp their visible light, infrared emissions, and other telltale indicators that make the planets detectable," Elston noted. "So if the more distant reaches of the disk are conducive to planet formation, they will be easier to find once astronomers start looking there," he said.

Elston and Lada found these large disks as part of a major survey for newborn celestial objects in mammoth molecular clouds in the constellations Orion and Perseus. The researchers worked at the National Science Foundation's 2.1-meter telescope at Kitt Peak National Observatory near Tucson, Arizona.

—from the University of Florida and the National Optical Astronomy Observatory

A large, nearly edge-on circumstellar disk forms a butterfly-shaped silhouette against a forming star. Located in the constellation Perseus, this huge disk of gas and dust is visible from Earth as a result of its orientation. Because the disk lies between Earth and the star, it effectively blocks the star's brightness and becomes visible in light scattered by dust.

Image: University of Florida and NOAO/AURA/NSF

On May 29, 2003, a team of scientists led by Brett Gladman of the University of British Columbia uncovered yet another Jovian satellite, raising the total count of Jupiter's moons to 61.

As its temporary designation of S/2003 J 21 indicates, it's the 21st moon discovered in 2003 around the gas giant. Like its newly found brethren, the object is only a few kilometers across. The team made the discovery with the 3.6-meter Canada-France-Hawaii Telescope atop Mauna Kea, Hawaii.

—from *Sky & Telescope*

Saturn, one of the windiest planets in the solar system, has recently had an unexpected and dramatic change in weather: Its equatorial winds have subsided. The slowdown was detected by a team of scientists from the Universidad Pais Vasco in Bilbao, Spain and Wellesley College in Massachusetts.

The Wide Field Planetary Camera on board the Hubble Space Telescope allowed the researchers to study the giant planet's wind velocity over a broad range of latitudes. They found that the equatorial winds measured from 1996 to 2001 were only about half as strong (990 kilometers, or 615 miles, per hour) as those measured in 1980 and 1981, when *Voyager* visited Saturn. (Winds then measured 1,700 kilometers, or about 1,060 miles, per hour.) The long seasonal cycle in Saturn's atmosphere and the equatorial shadowing by the planet's giant rings could account for the sudden slowdown in the equatorial winds, the scientists noted.

Rather than being tied to the deep interior of Saturn, and driven primarily by internal heat, the equatorial winds could be, in part, a shallow surface phenomenon affected by seasonal variations in sunlight. Saturn's equatorial region also has been the location of giant storm systems, such as those seen in 1990 and 1994. These storms may have induced strong dynamic changes, which might have resulted in the observed weakening of the equatorial winds.

—from Wellesley College

Society News

Mars Watch 2003: Set Your Eyes on Mars

On August 27, 2003 at 09:46:18 UT (2:46:18 a.m. Pacific Daylight Time), Mars will be closer to Earth than it has been for more than 50,000 years. During this opposition, Mars will be a beautiful sight in the sky for anyone who looks up. Because Mars is so close, it is also a great time for spacecraft to visit the Red Planet.

The culmination of Mars Watch 2003 is Planetfest '04 on January 2–4, 2004, when thousands will gather in Pasadena, California to witness the first *Mars Exploration Rover*'s arrival on the Red Planet.

The Planetary Society has launched an international celebration with Mars Watch 2003, a program encouraging people everywhere to take a closer look at this fascinating planet next door. Mars Watch 2003 will showcase a series of educational and observing activities, with events at sites all over the world, including star parties, science fiction film festivals, Mars talks, and more. The Society will host its own event on August 27, which we have proclaimed as "Mars Day."

Currently, we have many organizations and individuals hosting events—from Taiwan, to Vienna, to Kalamazoo. If you are interested in hosting a star party, planetarium show, lecture, or exhibit on Mars, please check *planetary.org/marswatch2003/*, or contact Vilia Zmuidzinas at *tps.vz@planetary.org*. We hope you will help us achieve our goal to have half of the world's population looking at, or thinking about, Mars!

—Vilia Zmuidzinas,
Events & Volunteer Coordinator

Solar Sail at Rockefeller Center

A 50-foot-tall solar sail from the Planetary Society's *Cosmos 1* spacecraft will be on display at the Rockefeller Center in New York City from July 29 through August 19, 2003. The sail will be part of the Centennial of Flight exhibit, which features displays from the past, present, and future of air and space flight. These will include, among others, a model of the Wright brothers' original Flyer, the controls in a space shuttle's cockpit, and a close look at NASA's futuristic space planes.

The sail on display represents one of the *Cosmos 1*'s eight blades. It is identical to the ones that will be used in the spacecraft's scheduled flight later this year and has been used in engineering tests conducted in Russia. The sail's surface is composed of a flexible, shiny Mylar-like material, designed to reflect light from the Sun and propel the spacecraft forward in the process.

For more on The Planetary Society's *Cosmos 1* solar sail project, check out the solar sailing section of our website at *planetary.org*.

—Amir Alexander, Web Editor

The Planetary Society Awards Scholarships

The Planetary Society has awarded academic scholarships to three promising young people interested in space exploration.

Devin Schrader, a science/astronomy and physics major at the University of Arizona, received The Planetary Society Scholarship for Space Studies. He is also interning at the university's Lunar and Planetary Laboratory in preparation for achieving his future objectives of earning a Ph.D. in planetary sciences and working for NASA.

Diane Chen, of Ontario, Canada, received the 2003 Planetary Society Jim and Lin Burke Fellowship to attend the International Space University's summer session in Strasbourg, France. Diane is a software product assurance engineer at MD Robotics, and she works on the Shuttle Remote Manipulator System program.

Francisco Muller Sanchez, a student at the University of Karlsruhe in Germany, also received the 2003 Planetary Society Jim and Lin Burke Fellowship to study this summer at the International Space University. Francisco is working on a master of science degree in information and communications technology, with a specialization in high frequency engineering.

The Society salutes these three young scholars, as well as our many members who make these prestigious scholarships possible. In particular, we thank Eric Tilenius, a former recipient of a scholarship from The Planetary Society, who generously funded the 2003 Planetary Society Jim and Lin Burke Fellowship.

—Linda Wong, Program Development Administrative Assistant

Recognize Someone Special: Honorary and Memorial Gifts

Would you like to honor the achievements of a family member, friend, or colleague? Or perhaps you want to celebrate a special occasion such as a wedding, anniversary, birth, or retirement? Or are you looking for a meaningful way to remember the life of a loved one, or send a message of sympathy to a friend or colleague at the time of a dear one's loss?

Many of our members answer these questions with a gift to The Planetary Society. Your honorary or memorial gift recognizes someone special and also supports space exploration and the search for extraterrestrial life. When you make an honorary or memorial gift, we will send the person honored or the family of the person memorialized an acknowledgment of your donation, without mention of the amount.

For more information about making an honorary or memorial gift, please contact Andrea Carroll at 626-793-5100, extension 214 or *andrea.carroll@planetary.org*.

—Andrea Carroll,
Director of Development

Show Your Society Spirit!

Planetary Society Cap
Our *planetary.org* cap is 100% cotton with an adjustable Velcro band. 1 lb.
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Planetary Society Mug
This 15-ounce, midnight-blue stoneware mug features our logo in microwavable metallic gold. 1 lb. **#675 $5.25**

Planetary Society Key Chain
This elegant key chain features our Planetary Society logo—planet, rings, and sailing ship—etched in black on solid brass.
1 lb. **#677 $16.00**

***We're Saving Space for You!* Bumper Sticker**
1 lb. **#695 $3.00**

Planetary Society License Plate Holder
Let your Planetary Society spirit travel with you on our members-only license plate holder. 2 lb. **#607 $10.00**

***Cosmos 1* Team Jacket**
Adult sizes: M, L, XL
1 lb. **#573 $60.00**

***Cosmos 1* T-Shirt**
Adult sizes: S, M, L, XL, XXL
1 lb. **#570 $25.00**

"Is Anyone Out There?" T-Shirt
Adult sizes: S, M, L, XL, XXL 1 lb. **#586 $19.95**

Future Martian T-Shirt
Child sizes: S, M, L 1 lb. **#565 $13.50**

Pale Blue Dot Poster
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An Explorer's Guide to Mars Poster
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Red/blue glasses included.
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In *Mars from Deimos*, a luminous Mars adorns the night sky above its rocky satellite. Five spacecraft—*Spirit*, *Opportunity*, *Mars Express*, *Beagle 2*, and *Nozomi*—are now on their way to the Red Planet. If all goes well, they will join *Mars Global Surveyor* and *Mars Odyssey* to form an unprecedented fleet of seven robotic explorers at our neighboring world.

Ludek Pesek (1919–1999) was a space artist, science and science fiction writer, and photographer who lived and worked in Stafa, Switzerland. His work was first seen in the United States when *National Geographic* magazine commissioned a series of illustrations on the discoveries made by the *Mariner* missions to Mars (see the August 1970 and February 1973 issues). Many of Pesek's most important paintings of Mars reside at the Smithsonian Institution's National Air and Space Museum in Washington, DC. Painting printed courtesy of Beatrice Pesek

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