The PLANETARY REPORT

Volume XXI Number 3 May/June 2001

To Mars—Step By Step

On the Cover:

In the afternoons of Mars' northern summer, it's not uncommon to see clouds over the planet's Tharsis volcanoes, visible just below center in this image. The bright white cloud at left hovers over Olympus Mons. This portrait, completed on April 10, 1999, is a computer-enhanced color composite of red and blue image strips taken by *Mars Global Surveyor* in March 1999. Image: MSSS/NASA

From The Editor

This year, Planetary Society activities will be dominated by *Cosmos 1*, our project to launch the first solar sail. So far the press has focused on either the technical aspects of the story or the possibility that a membership group, and not a space agency, may be the first entity to launch such a craft. But there is another aspect of the story, a personal one, that we will be telling in this issue.

In my 20 years at the Society, I've been privileged to meet and become friends with fascinating people from around the world, and this has been one of the greatest benefits of working here. Also, I've watched extraordinary relationships develop, and none has been more fruitful than that between Lou Friedman and Slava Linkin. I want to tell the story of their friendship because, without it, there would be no *Cosmos 1*. This story teaches us that, whatever the forces of history, human relationships are what really move the world forward.

So in this issue we'll depart slightly from our accustomed technical and scientific subject matter and examine a spaceflight project from a more personal angle. Also, watch for us to continue our in-depth coverage of *Cosmos 1*, which we will feature in every issue at least to the end of the year.

Cosmos 1 is an extraordinary effort, involving not only spacecraft scientists and engineers and our sponsor, Cosmos Studios, but also each and every member of The Planetary Society. Ours is truly a team with 100,000 members. We are all involved in every step, each dependent on the others. And together we will see *Cosmos 1* fly.

—*Charlene M. Anderson*

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Members' **Dialogue**

Solar Sail

I would like to thank you for starting the solar sail project. That endeavor probably saved you a member—I was seriously considering quitting the Society, mostly due to your all too deep involvement in SETI at the expense of other, more active measures toward space exploration. At our current stage of technical development, SETI is very unlikely to succeed, and even if some suspicious signal were detected, it would have little, if any, impact on our ability to live in space—which, I presume, is a goal shared by all true space enthusiasts.

Therefore, more serious involvement in practical space exploration is a welcome change and a step in the right direction. I hope it will become the dominant field of activity for the Society, in addition to pro-space lobbying and promotion, and sponsoring other useful activities like NEO research programs worldwide.

Instead of searching for alien extraterrestrial civilizations, we should rather work hard toward building our own extraterrestrial civilization, which I hope will become the main goal of The Planetary Society.
—ZENON KULPA,
Warsaw, Poland

I do not understand how you can claim the solar sail mission is the "first space mission undertaken by a public membership organization" (see the March/April 2001 issue of *The Planetary Report*). The Planetary Society must be unaware of the last 40 years of satellite building by The Radio Amateur Satellite Corporation (Amsat) and its predecessor, Project Oscar (Orbiting Satellite Carrying Amateur Radio). The first space mission by a membership organization was Oscar 1, launched on December 12, 1961. This was the very first nongovernmental space mission, beating Telstar by six months.

In November 2000, Amsat launched its largest and most ambitious satellite, Phase 3D, renamed Oscar 40 upon reaching orbit. This 600-kilogram (1,323-pound) spacecraft cost over $2 million, paid mostly by contributions from Amsat members around the world.

My hope is that The Planetary Society and Amsat might work together to build space missions making use of Amsat's four decades of experience building low-cost member-supported spacecraft.
—DANIEL SCHULTZ,
Greenbelt, Maryland

We apologize to Amsat and all of its dedicated members. In making the statement we were thinking only of space-advocacy organizations. Of course, Amsat qualifies broadly that way, although its main interest is communications. Amsat deserves full credit for being the first membership organization to carry out a privately funded space mission. I hope we will be cooperating in the future.
—Louis D. Friedman,
Executive Director

Pluto Practicalities

The March/April 2001 issue of *The Planetary Report* was incorrect in stating that NASA's "announcement of opportunity" requires reaching Pluto and Charon in 2015. This was amended. The actual requirement is to be in the Pluto-Charon system by 2020.

The amendment was made due to pressure from the [space] community regarding the required launch by 2004 and a 2015 arrival. The 2004 [launch date] was driven by a Jupiter flyby that would be required by any conventional propulsion-driven probe.

Comments from NASA's Office of Space Science released on SPACE.com suggest that the requirements were changed to encourage alternate propulsion concepts. Conventional propulsion systems generally allow for a flyby spacecraft supplying the opportunity to collect Pluto data only during the flyby. Alternate propulsion technologies should permit a more complete mission, such as an orbiter that could obtain data for long durations at close range to Pluto.
—TRAVIS S. TAYLOR,
Huntsville, Alabama

Although an exploratory probe of Pluto would be of some interest, I do not see it as cost-effective at this time—especially compared with other opportunities that beckon.

Because of the great distance and lack of a massive object in the vicinity to help capture a spacecraft into orbit, a Pluto probe would have to make a very brief visit. And the planet is likely not all that interesting to begin with.

There will be time to visit Pluto after the development of fusion-powered rockets. The timing of the launch will then be less critical, the trip will be faster, there will be spare power for settling into orbit around the planet, and the whole venture will probably cost a lot less.
—DAVE FAFARMAN,
Richmond, California

I believe the main reason to explore space is to find out what is out there. I do not feel we should ignore exploration of the outer reaches of our solar system to concentrate solely on missions closer to home.

In essence, I feel NASA should lift its stop-work order on the *Pluto-Kuiper Express* mission. We need to explore and determine the extent of our solar system before we stop to smell the roses, so to speak.
—LAWRENCE J. GENTRY,
Lompoc, California

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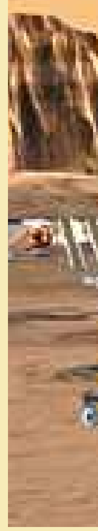
We Can All Go

Left: We've already passed through the first two phases of Mars exploration: getting there and finding out what the place is like. The success of Mars Pathfinder *has moved us into the third phase: going often, landing, and someday bringing samples back. In this painting, robot explorers scout the Red Planet's surface for future landing sites.*

Painting: David Egge



We are transported to the planet's surface. The temperature is –40 degrees Fahrenheit—a typical day. Wispy clouds skirt across the thin, reddish-ocher sky. We navigate over a rocky slope and peer for the first time into the mouth of a ravine, its walls apparently shaped by flowing water. The erosion seems relatively recent. Could water still be percolating to the surface, then evaporating? Is there evidence of life below the surface? We press on for clues.

All this can become reality within the next decade.

Until now, space exploration has involved either robotic or human expeditions. We launch probes to distant worlds to collect scientific data. Closer to home, humans regularly travel to Earth orbit and have ventured to the Moon.

Robotic missions are relatively inexpensive, costing, on average, several hundred million dollars. By contrast, human exploration is extremely expensive. To place the first humans on the Moon consumed, at one point, about 5 percent of the annual federal budget and took nearly a decade to complete. The price tag for a human expedition to Mars—a goal that generates broad public interest—is many tens of billions of dollars and could consume at least another decade.

Mars beckons for exploration—robotic or human. Rather than argue about which approach is preferable, a third way bridges the gap. The Planetary Society has dubbed this approach Mars Outposts.

Mars Outposts would consist of specially designated research sites on the Red Planet, equipped with permanent communications, navigational systems, and other technologies to support intensive robotic missions and, most important, vicarious public participation. The areas would become, in a sense, "Martian Antarcticas," places of high scientific interest where researchers from around the world could collaborate to learn about the planet.

At the sites, rovers, balloons, and other probes would comprehensively investigate the surrounding terrain. Thanks to continuous signals broadcast to Earth and distributed through the Internet, humans worldwide would be able to participate in the exploration of the planet. For instance, via camera lenses on a rover, students could explore the landscape and command the vehicle, maneuvering through dry river basins and along the polar regions. Mars is a magnificent place. A deep swath cutting across the face of Mars dwarfs America's Grand Canyon. Olympus Mons rises more than twice the height of Mount Everest.

With Mars Outposts, the whole world could collectively experience the thrill of exploring another world. We could all become the Lewises and Clarks of Mars.

Furthermore, the Mars Outposts approach incrementally establishes the infrastructure needed for human expeditions and thus greatly reduces costs and increases safety. Also, the outposts could become future landing sites. The same communications and navigational systems used for the robotic probes could later support a human mission. The robotic infrastructure, for instance, could facilitate the production and storage of propellant and also breathable oxygen produced on Mars from the planet's thin, carbon dioxide atmosphere—thereby reducing the payloads launched from Earth to support initial robotic sample return and subsequent human exploration and return to Earth.

to Mars

by Bruce Murray and Louis D. Friedman

The next logical step in Mars exploration is to establish a permanent presence on the planet. An early robotic outpost might look something like this: solar arrays surround a resource utilization system, while in the foreground two rovers assemble a drill. *Illustration: JPL/NASA*

Rovers are extremely efficient little explorers. This NASA illustration shows the Mars 2003 ***Rover as it sets off to roam the surface of the Red Planet. The spacecraft is scheduled to launch in June 2003 and will land on Mars in January 2004. Collapsed at right is the airbag shell that shielded the rover's landing.*** *Illustration: JPL/NASA*

Additionally, the outposts would allow scientists and engineers to determine the tasks best accomplished by robotic technologies and those more appropriately performed by humans. The new paradigm of human-machine symbiosis could be built step by step.

Humans will travel to Mars; we just don't know when. The next step toward realizing this dream could be aboard the International Space Station—there conducting research on keeping humans healthy in space over extended periods and preparing them for the long and arduous expedition to Mars. The station also could be used to develop habitat technology for a Martian crew.

As the space station is an international endeavor, so, too, will be a human expedition to Mars. And so, too, would be the Mars Outposts. Together, all would share the costs, risks, and opportunities of robotically learning about Mars and progressing to the human phase. The outposts would catalyze the transition to direct probing of the habitability of Mars.

It is a propitious time for the new US president to initiate the Mars Outposts program. New discoveries from *Mars Global Surveyor*, now orbiting the Red Planet, strongly suggest evidence of the presence of water and thus places to locate outposts.

To begin the process, outposts would be selected on Mars' surface, then promising sites would be expanded at an affordable level. Over time, these areas would become familiar places, focusing scientific research and inspiring a generation. The outposts may therefore offer a clear vision of the future as well as a new way of exploration—the raison d'être of our nation's civil space program.

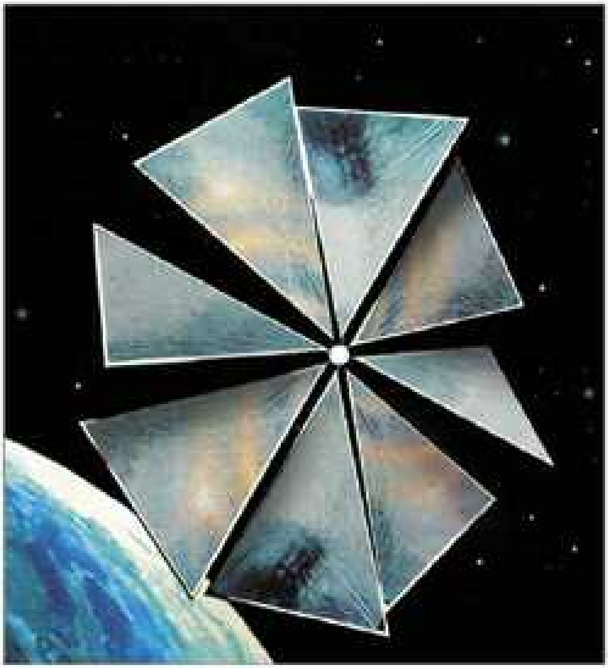
We are blessed to live at a time when we are able not only to dream about distant worlds but to explore them together. Ours is the first generation of the Space Age. It can be our fortune to reach into the heavens as one and open our eyes upon a new world.

Bruce Murray is President of The Planetary Society, and Louis D. Friedman is the Society's Executive Director.

Below: These astronauts, protected by sturdy space suits, are going about their business in the middle of a Martian dust storm. A scene like this—our ultimate goal—will more likely happen if robotic outposts pave the way. *Illustration: Paul DiMare for NASA*

TO FLY A S

A Story of



Cosmos 1, ***the first solar sail, will orbit Earth on its maiden voyage.*** ***Illustration: Babakin Space Center***

In August 1991 a team from The Planetary Society and the former Soviet Union got together to test the **Marsokhod** ***on the bleak, Mars-like terrain of Siberia's Kamchatka peninsula. Here a few team members size up their surroundings before setting out. From left to right are Harris M. "Bud" Schurmeier, veteran Jet Propulsion Laboratory (JPL) project manager and Planetary Society consultant; Alexander Kermurjian, designer of the*** **Marsokhod** ***and*** **Lunokhod** ***rovers; the Society's executive director, Louis Friedman; aerospace consultant Thomas Heinsheimer; and Viacheslav "Slava" Linkin of the Soviet Space Research Institute (IKI). Another team member, Roger Bourke of JPL, took the picture.***

This is a story of friendship—friendship forged during the last flare of the Cold War, enabled by changing tides of history, and strengthened by a passionate desire to explore other worlds. It tells how personal relationships defied and outlasted governments, how political barriers fell before shared dreams, and how a small group of private citizens came to accomplish something government agencies could not.

This is the story of how The Planetary Society came to fly the first solar sail mission.

Building Bridges

The story begins in 1983, when The Planetary Society was barely out of its fledgling stage—although at three years old it was already the largest space interest group on Earth. Early that year, Roald Sagdeev, a plasma physicist and head of the Space Research Institute (IKI) in Moscow, as well as the youngest person ever elected to the Soviet Academy of Sciences, visited the United States in hopes of forging better ties between American and Russian space scientists.

At the time, no official channel between US and Soviet space agencies existed. "It was the time of Star Wars/Evil Empire rhetoric," Roald remembers. Bridges would have to be built on an unofficial basis. "Personal relations played a tremendous role," Roald says.

In 1976, when he had visited the United States as a member of a Soviet delegation, Roald met Society President Carl Sagan. They became friends, and Carl kept him informed as the Society was founded and then developed. An unofficial player in the space arena, the Society could operate where governments could not.

In 1983, Roald invited Carl, Society Vice President Bruce Murray, and Ex-

OLAR SAIL: *Friendship*

BY CHARLENE M. ANDERSON

It was once highly unusual for an American to be allowed to poke around behind the scenes at a Soviet space agency, but Louis Friedman was given that rare opportunity in September 1983. Here he examines one of the Venera *spacecraft that would later land on Venus. (Officials at IKI generously offered Lou permission to take a picture, but because he hadn't thought to pack a camera, they took this photo for him.)* Photo: Soviet Space Research Institute

ecutive Director Louis (Lou) Friedman to the Soviet Union to explore which initiatives they could pursue together. Since Lou was the officer with staff responsibility, he was selected to make the trip to Moscow.

Lou arrived in the Soviet capital at the end of September, just 10 days after Russian fighters shot down Korean Airlines flight 007 over the Sakhalin Islands, prompting President Ronald Reagan to make his famous (or infamous) "Evil Empire" speech about the Soviet Union. The flight 007 tragedy worsened already poor relations between the two nations—several weeks earlier, US government restrictions had made it impossible for a group of American space scientists to attend an international meeting in Moscow.

That first night in Moscow, Lou sat in Roald's office and listened to Soviet Premier Yuri Andropov's speech responding to Reagan's Evil Empire oration. It was not an auspicious way to begin building international relations.

Still, led by Roald, a small group of Soviet scientists were intent on establishing relationships that could lead to cooperation between specialists in the two antagonistic nations. The Soviets would not be junior partners; at the time they had two highly capable spacecraft, *Veneras 15* and *16*, heading toward Venus. Meanwhile, the US planetary program was at a near standstill, hobbled by NASA's consuming drive to build the space shuttle.

The Soviets sought cooperation between equals. They wistfully recalled the cooperative spirit that flowered briefly during the *Apollo-Soyuz* mission in the early 1970s. Then, American and Soviet scientists had walked each other's hallways, greeted each other as friends, and worked toward a common goal: to link the human spaceflight programs of the competing nations so that together they could achieve more.

The Plot Thickens

Still, Lou was puzzled as to why Soviet scientists, in a nation so obviously proud of its space achievements, would push so hard for cooperation with American researchers. He asked Leonid Ksanfomality, a scientist at the Vernadsky Institute in Moscow.

Ksanfomality explained that by bringing in foreign scientists whose experiments were funded by their own countries, the Soviets could accomplish more with less cost. Even then, there was economic pressure on the Soviet space program.

Additionally, Lou had wondered why he, the head of an American public interest group, had been invited into the heart of the Soviet space program. Once in Moscow, he realized that The Planetary Society occupied a unique position. Its officers possessed solid scientific credentials and participated actively in the space program. But the Society was not government funded; it was independent and therefore unbur-

In 1985, Roald Sagdeev paid a visit to The Planetary Society's former headquarters, a tiny rented office in Pasadena.

Photo: Louis Friedman

A Fine Romance

In 1987, the Soviet government asked Roald Sagdeev to organize an international conference to commemorate the 30th anniversary of *Sputnik 1*. That first launch of the Space Age had shocked the people of the United States and spurred the administration of Dwight D. Eisenhower to create NASA, among other actions. The US government would not be a partner in celebrating the accomplishments of *Sputnik*; still, Roald wanted to ensure that both major spacefaring nations were represented at the conference. Needing an informal coordinator in the United States, he asked Lou Friedman to develop a list of invitees.

On the list Lou included Susan Eisenhower, who, as president of the Eisenhower World Affairs Institute, actively studied the East-West relationships that had occupied so much of her grandfather's time as president of the United States. As Roald recalls, "The name of my future wife was on the list Lou provided; that was the reason I first approached her."

They were married in 1990. Roald resigned as director of the Russian Space Research Institute and moved to the United States, where he now serves as director of the East-West Space Science Center of the University of Maryland at College Park. Susan has chronicled their romance in *Breaking Free: A Memoir of Love and Revolution* (Farrar, Straus & Giroux, 1995).
—*CMA*

In the late 1980s, Lou and Slava teamed up with Jacques Blamont of France's Centre National d'Études Spatiales to launch the Mars Balloon test program. In the fall of 1990, we successfully tested the balloon and its "Snake" guide rope on the Mars-like sands of California's Mojave Desert. The balloon, designed to drift along dragging test instruments housed in the Snake across the Red Planet's surface, was scheduled to fly on Russia's doomed Mars '96 *mission.*

Photos: Susan Lendroth (above), Charlene M. Anderson (above right)

dened by bureaucratic or diplomatic concerns. The Society was just what Roald was looking for to build a bridge between nations.

Roald proposed that The Planetary Society organize and sponsor a meeting among Soviet and American space scientists, as well as a few select friends, to coincide with the 1984 gathering in Graz, Austria of COSPAR, the Committee on Space Research of the International Council of Scientific Unions. In a neutral location, citizens of antagonistic nations could come together as colleagues and begin to develop relationships that might lead to journeys to other worlds. Roald felt that such a meeting would be historic. Carl agreed to serve as chairman, and he, Bruce, and Lou would work together to organize the meeting.

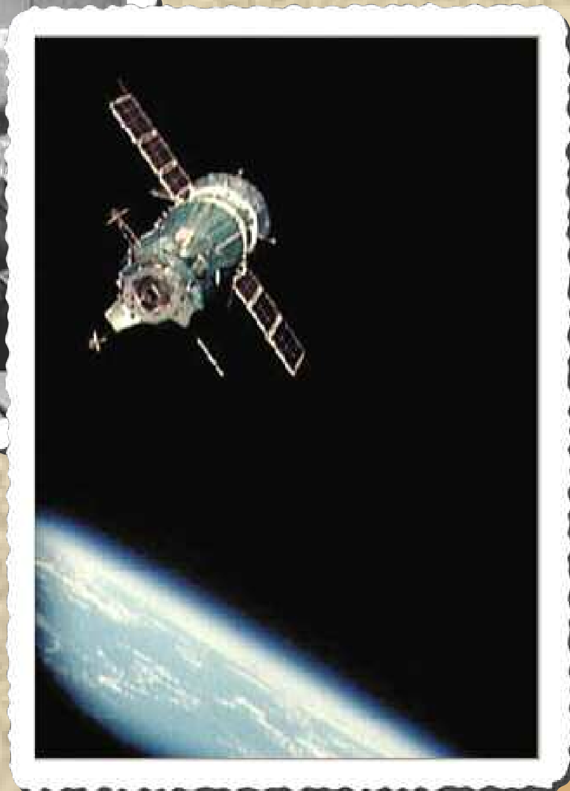
The trip that began so inauspiciously ended with new hope.

The Planetary Society's Board of Directors enthusiastically embraced Roald's proposal, though to organize such a meeting would prove a delicate operation. It would be unsanctioned by official bodies in either the US or the USSR, and concerns were raised that the Society's involvement might alienate NASA management. Also, Lou wanted to avoid eliciting any cynicism about the Society's motives.

Roald and Carl agreed the participants would attend as individuals, not as representatives of their governments. Nor would any official sanction be sought. The result of the meeting would be a series of recommendations addressed to The Planetary Society rather than to government agencies.

Significant resolutions coming out of the meeting included opportunities for immediate cooperation, such as Venus

Above: Thomas O. Paine, who served as NASA administrator from March 1969 to September 1970, dreamed up the Apollo-Soyuz *mission to foster cooperation, not competition, between spacefaring nations. Here he is (at center) with mission controllers on April 17, 1970 as the crew of* Apollo 13 *safely splashed down.*



Right: In this photo, captured from the rendezvous window of Apollo, *the Soviet* Soyuz *spacecraft floats against the dark sky over Earth's blue horizon on July 17, 1975. But the spirit of friendship that conceived* Apollo-Soyuz *would wither. With the 1980s came the Evil Empire mentality and the Star Wars program—snuffing out, temporarily, American-Soviet partnership in space exploration.*

Photos: NASA

radar exchange, Mars science joint planning, and scientist exchanges on future missions. It was also suggested that The Planetary Society be instrumental in fostering American-Soviet cooperation in planetary exploration.

Enter Slava

In November 1985, Lou's relationship with the Russians deepened. He met the man who is probably his closest collaborator and best friend, Viacheslav Linkin—whom everyone at The Planetary Society now calls Slava.

On that fateful November day, Roald invited Lou to come by his office at IKI for lunch and a "private chat." Lou was surprised upon his arrival to find they would be joined by Linkin. He was suspicious why Roald would include a third party in a "private" meeting. Soviets visiting the United States were required to travel in pairs because of official fears that a lone traveler might be induced to spill secrets. Lou wondered if Slava was present to keep an eye on Roald.

Lou had reason to be suspicious. When he returned Roald's hospitality by inviting him to visit The Planetary Society, Roald was accompanied everywhere by an "arms-control specialist" called Yuri, who was almost certainly a KGB agent assigned to watch him. (Although we figured he was KGB, Yuri was nonetheless very pleasant, and we enjoyed hosting him. In fact, Society old-timers remember him fondly.)

Lou's initial impression of Slava, noted in his journal, was positive: "Nice fellow, sharp and clearly good— but political? Maybe he's a comer." In Roald's office, Slava gave Lou inside information on the Soviets' mission to Phobos, the larger Martian moon. Lou was "impressed by Slava's openness and his free-

An Expansive Future

Apollo-Soyuz was the brainchild of Thomas O. Paine, who led NASA during the first *Apollo* landings on the Moon. Seeing an expansive future for humanity out among the planets, Tom sought a goal for NASA of sending explorers beyond the Moon to Mars. But the political tides were not conducive to launching such an endeavor. The Nixon administration curtailed the American space program and limited human missions to Earth orbit.

Tom left NASA in 1970. However, he did not leave behind his interest in space. A few years later, Tom Paine became an influential member of The Planetary Society's Board of Directors. President Ronald Reagan asked him to chair the National Commission on Space, which produced its landmark report, "Pioneering the Space Frontier," in 1986. Tom died in 1992. —*CMA*

Above: *In August 1993 the Society organized a second expedition to Kamchatka—this time to test the rover expected to explore the Red Planet as part of* Mars '96. *Wet (and very un-Mars-like) weather forced team members to fashion a plastic raincoat for the rover.*
Photo: George Powell

Go figure! The Mars Rover performed splendidly in all the tests we put it through. That is, until the day we trotted it out for NASA Administrator Daniel Goldin at the Jet Propulsion Laboratory. The rover's obstacle-avoidance computer program malfunctioned, and it contorted wildly trying to get past a barrier. That's Viktor Kerzhanovich wondering what went wrong. Photo: Charlene M. Anderson

Right: *Along the way, unexpected events have expanded the meaning of the term "international cooperation." During the first rover expedition to Kamchatka, American and Soviet scientists teamed up to battle not bureaucracy but mud.* Photo: Roger Bourke

dom to share information about the mission."

(It should also be mentioned that the Soviets harbored suspicions of Lou and his motives. Why was he so interested in everything Russian? Plus, Lou was a compulsive jogger and loved to take early-morning runs through Gorky Park—something unheard of in Moscow. Rumors circulated that Lou was a CIA agent. Who else would do such crazy things?)

Close Collaborators

After Roald's introduction, Lou and Slava began a collaboration that has progressed through many steps leading to the solar sail. Working with Jacques Blamont, the highly respected French scientist and Planetary Society Advisory Council member, they launched the 1988 Mars Balloon test program. (See "From the Moon Rover to the Mars Rover" in the September/October 1988 issue of *The Planetary Report.*)

In 1990 the two turned their attention to the *Marsokhod*, the robotic rover designed by Alexander Kemurjian, a hero of the siege of Leningrad and designer of the *Lunakhod* that traversed the Moon. The Society's Mars Rover project took teams to the remote Kamchatka peninsula as well as to the great American desert, culminating in a Death Valley expedition where Society members joined Russian, Hungarian, and French scientists in tracking the rover across some of the most desolate terrain on Earth.

The ill-fated *Mars '96*, which we had hoped would carry both the Mars Balloon and Rover, instead carried a Planetary Society-produced CD-ROM called "Visions of Mars." Slava saw to it that the CD was affixed to the spacecraft. Unfortunately, because of a launch failure, the spacecraft transported it to the bottom of the Pacific Ocean instead of to Mars.

In 1999, the determined duo again tried to reach the Red Planet, this time on NASA's *Mars Polar Lander*. Slava had been selected by the Jet Propulsion Laboratory (JPL) to build a Lidar instrument to measure dust density in the atmosphere. Piggybacking on the

Lidar was The Planetary Society's Mars Microphone, which we hoped would bring us the first sounds fromanother world. At least it reached the planet, but it was lost with the lander on December 3, 1999.

Lou comments that "these experiences gave us a history of realistic working relationships." All the ups and downs—personal, professional, and political—produced a thorough understanding of each other's strengths and weaknesses and also forged the mutual respect and trust that enabled them to tackle something as audacious as a private solar sail mission.

Pushing Past Obstacles

Despite the setbacks, Lou and Slava never slowed down and never stopped trying. It's in neither of their natures to quit, and in that and many other ways they are alike, which may partly explain their friendship. Viktor Kerzhanovich has known them both for many years; he worked closely with Slava at IKI before moving to the United States. He now works at JPL, only a few miles from The Planetary Society office (see "Exploring With Aerobots: A New Way to See the Worlds" in the September/October 1999 issue of *The Planetary Report*). Viktor has closely watched Lou's developing relations with the Russian space program and his friendship with Slava.

Viktor believes Lou gets on so well with Russians because of his personality: "enthusiastic, without too many prejudices. He saw opportunities others didn't see." When Lou first made contact with Soviet space scientists, their program was broader than the American effort. Lou saw ways cooperation could help both sides. Plus, "Lou likes to fight, to push past obstacles," and building bridges between the two sides provided many opportunities to do both.

Slava, in Viktor's estimation, shares some of the same traits: "First is his enthusiasm. But he is also a fighter—in Russia he is an uncompromising fighter. He is also broad-minded and has proved that he can deliver."

Still, all that these two friends have accomplished would not have been possible without Roald and the power he wielded at that time in the Soviet Union. An amazing politician, he guided IKI through some perilous political waters. With Mikhail Gorbachev's rise to power, Roald became a valued arms-control adviser and traveled to summit meetings with the Soviet premier.

Viktor points out that Slava could work so closely with Lou only on Roald's authority. "Without him, nothing would have happened; it all would have been lost in bureaucracy."

On The Planetary Society side, Lou could not have proceeded so aggressively without the support of his bosses, Carl Sagan and Bruce Murray. They had made international cooperation in planetary exploration a major goal for the Society and recognized that person-to-person contact was the best way to advance during the 1980s and early 1990s. As Lou recalls, through those years they often supported him "in the face of a hostile environment generated by NASA and many, but notably not all, professional colleagues." The bonds forged in such times of adversity are perhaps all the stronger today.

So now, Lou and Slava are off on another adventure: to fly a space mission with private sponsorship, using converted military rockets, developing new technologies, and going where no one really has gone before. It's just the sort of challenge they relish. This fall the world will watch as their friendship culminates in *Cosmos 1*, and The Planetary Society launches the first solar sail.

Charlene M. Anderson is Associate Director of The Planetary Society.

Fast forward to the present—and the latest fruit of a special friendship. Here we look down the length of a solar sail test blade spread out on the floor of Russia's NPO Lavochkin Center, where the spacecraft is being built.
Photo: Babakin Space Center

A NEAR PERFECT LANDING

by Melanie Melton

After an incredibly successful year in orbit around asteroid 433 Eros, the *Near Earth Asteroid Rendezvous (NEAR) Shoemaker* spacecraft was approaching the end of its primary mission, its fuel and funding nearly depleted. Mission scientists decided to honor the "little spacecraft that could" with yet another place in the record books—a chance to make the first-ever landing on an asteroid.

NEAR Shoemaker initially earned its place in history on February 14, 2000, when it became the first spacecraft to orbit an asteroid. Since then, the spacecraft gathered more than 10 times the amount of data originally hoped for by scientists. Included in the data are more than 150,000 images of Eros, providing a detailed map of the entire surface of the asteroid.

But *NEAR Shoemaker*'s time had come to a close. With nothing to lose (its primary mission essentially over) and unique information to be gained, mission engineers decided to attempt to land the spacecraft on Eros—despite the fact that *NEAR* was never designed to touch down on a surface. Using detailed image and gravitational maps of the asteroid, engineers proceeded with their daring plan.

On February 12, 2001, commands were relayed to *NEAR* to initiate a four-hour descent to the surface of Eros. Sixty-nine images were taken as the spacecraft closed in on its targeted landing site, a saddle-shaped depression called Himeros. At 3:02 p.m. EST, *NEAR* gently descended to the asteroid's surface, bounced a little, then rested, tilted over on one side. Not only did it survive the landing—touching down at the slow rate of 1.9 meters per second (4 miles per hour)—but it continued to transmit a signal.

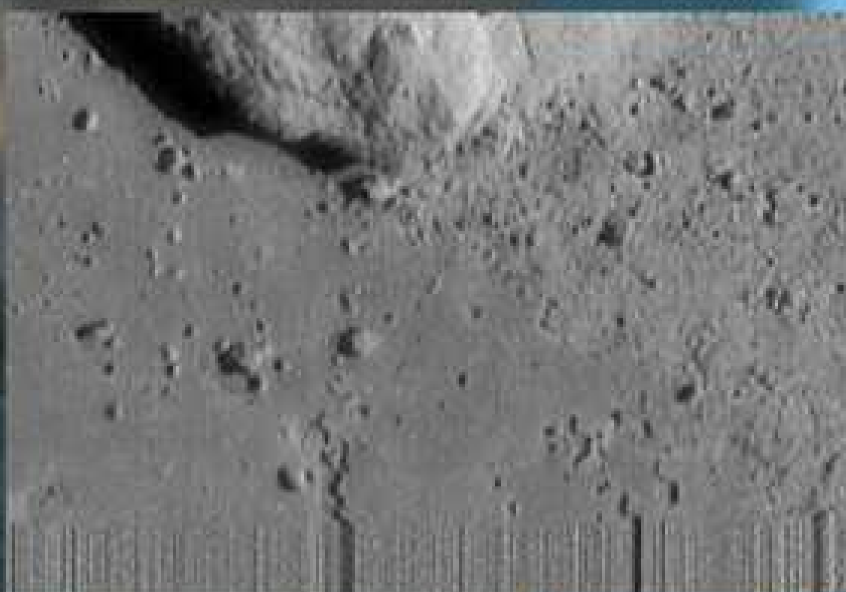
Some, but not all, of *NEAR*'s instruments continued to work after landing. Not having been designed to take close-up images, the camera was useless. However, scientists were able to utilize the gamma ray spectrometer (GRS). From orbit, the GRS could study only the top few microns of surface material. Now, sitting on the surface, the GRS was able to study surface composition

(continued on page 14)

Inset: Engineers prepare Near Earth Asteroid Rendezvous (NEAR) *for loading onto a Delta 7925—the smallest rocket used to launch a planetary mission. In this photo the spacecraft's solar panels are folded down.*

Background: A tale of triumph began here. Even in the face of adversity, the NEAR Shoemaker *spacecraft outdid itself to give us unprecedented views of asteroids Eros and Mathilde—not to mention of our own Antarctic.* NEAR *launched flawlessly on February 17, 1996.*

Photos: Johns Hopkins University, Applied Physics Lab

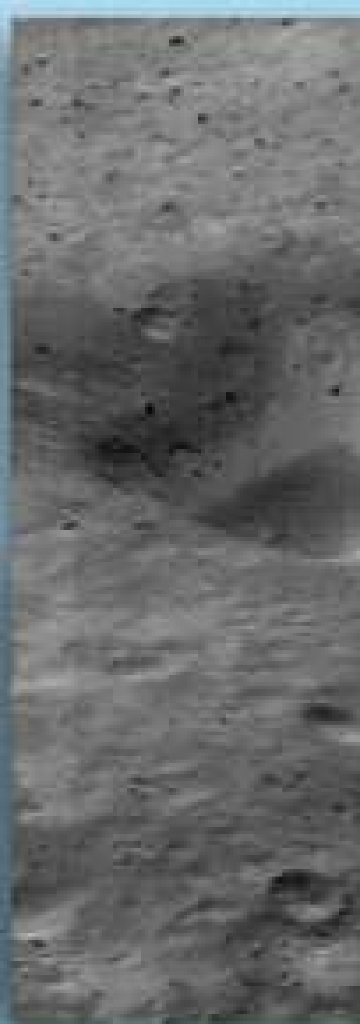


***Left:** The arrow points to* NEAR*'s landing site. Chosen mostly because of the orbital geometry of the spacecraft and the tumbling asteroid, the saddle-shaped feature known as Himeros has very few craters, indicating a relatively young surface. In this image, south is to the top. This image mosaic was taken December 3, 2000 at an altitude of 200 kilometers (12 miles).*

***Middle:** Taken 700 meters from the surface, this image is 33 meters across. The large oblong rock casting a shadow (near the lower edge of the image) is approximately 4.3 meters across.*

***Bottom:** This image, taken 120 meters from the surface, is the last received from* NEAR *before the spacecraft touched down on the surface of Eros. The lines on the bottom quarter of the image are a result of loss of signal. The image itself is 6 meters across. The boulder at the top middle of the image is 4 meters across. In the lower middle of the image, just above where the signal is lost, are two areas of collapsed terrain. Also note the difference between the terrain in the upper right corner and in the lower left. This is an example of the sharp boundaries between the rough and smooth landscape that puzzle scientists.*

Images: JPL/NASA



Left: Within the large crater, one can see several smaller craters. This image was taken December 16, 2000 from 37 kilometers (22 miles) above the surface of Eros.

Right: This image, taken January 11, 2001 at a distance of 38 kilometers (23 miles) above the surface of Eros, shows a crater with brighter-than-usual walls. Apparently the original dark surface material slid down the crater walls, revealing lighter-colored subsurface rocks.

Below left: The craters in these two images have unusually flat surfaces at the bottom of the crater depression. Scientists believe the flat appearance results from material sliding down the crater walls and "pooling" on the crater floor. The image on the left, taken January 27, 2001 at a height of 13.5 kilometers (8 miles) above the surface, is approximately 550 meters across. The image on the right was taken January 26, 2001 from 4.9 kilometers (3 miles) away. This image is about 230 meters across. *Images: JPL/NASA*

(continued from page 12)

down to a depth of 10 centimeters (4 inches). Funding for the mission was extended, allowing scientists to download "bonus" GRS readings. Here are some of the interesting findings to date.

The Structure of Eros

Before *NEAR Shoemaker*, scientists didn't know if Eros was a large rock or a loose jumble of smaller boulders simply held together by gravity. *NEAR* revealed Eros to be one large, solid rock. A series of deep cracks and grooves appear to run throughout the asteroid, though not enough to jeopardize its structure.

Anything we can learn about an asteroid's internal structural is of interest to scientists studying potential asteroid impacts on Earth. If an asteroid were on a collision course with Earth, one option to save our planet would be to try and destroy the asteroid (as attempted in the films *Deep Impact* and *Armageddon*). Therefore, the more information we have, the better prepared we will be for possible threats to our planet in the future.

The Composition of Eros

Before *NEAR*, scientists believed Eros was composed mostly of metallic iron mixed with iron and magnesium silicates. Instead, *NEAR* found an even mix of metals and silicates (rocks) on the surface. In fact, it now seems Eros is the largest known member of the most primitive class of meteorites, called chondrites.

While the composition of Eros' surface is similar to that of a typical chondrite, it's not a perfect match. Eros doesn't have as much sulfur as one would usually find on a chondrite. If Eros began its life with the standard ratio of sulfur among its many other elements, something must have happened to cause the sulfur to evaporate. Was Eros exposed to high temperatures sometime during its long life?

Eros' composition was determined by surveying only the top few microns of the asteroid's surface. When *NEAR Shoemaker* landed on Eros, its GRS was able to take more detailed readings of the surface. Scientists are busy examining the data. While the GRS can't detect sulfur, it is capable of detecting radioactive potassium. Potassium, like sulfur, is a volatile element that evaporates when exposed to high temperatures. If the GRS detected plenty of potassium in the last data from *NEAR*, this would support the classification of Eros as a chondrite.

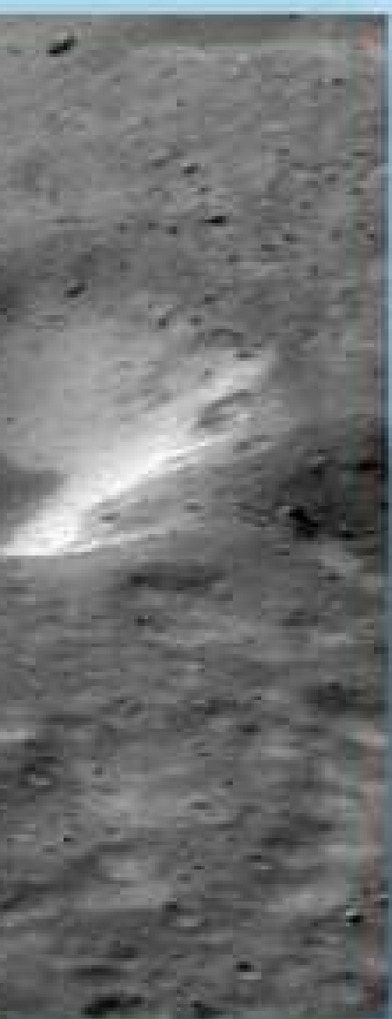
Surface Features

During its year in orbit, *NEAR* continued to reveal strange and interesting features of Eros via its onboard camera and instruments, right up to the last image the spacecraft sent back.

Craters

Eros has more than 100,000 craters larger than 15 meters in diameter, yet there is a mysterious absence of small craters (when compared with the Moon, Mercury, and other cratered surfaces). Is there some force at work on Eros that erases small craters?

Some of the existing craters appear to have flat bottoms, where fine dust and small rocks have slid down the crater walls and



Right: This boulder-covered region is located on the southwestern slope of Himeros, the large saddle-shaped depression on Eros. Scientists are not sure where all these boulders (over 1 million house-size boulders and larger) came from. This image mosaic was taken June 14, 2000 from 52 kilometers (31 miles) above the surface.

Left: This image shows an example of the sharp boundaries between two types of terrain. In the lower right corner, the surface appearance suggests a smoothing over of the craters, while in the upper left corner, the terrain is much rougher. The differing landscape is divided by a sharp line down the middle of the image. This image was taken January 7, 2001 from 35 kilometers (21 miles) above the surface of Eros.

Images: JPL/NASA

"pooled" on the crater floor. Scientists were surprised to see evidence of so much movement. Rocks roll down hills on Earth because of gravity. While Eros does exhibit gravity, it is thousands of times less than Earth's. However, even that slight amount seems to have a visible effect on surface materials.

Boulders

While Eros appears to be missing small craters, a tremendous number of large boulders are scattered across its surface—about 1 million house-size or larger boulders, to be exact. These boulders are greater in size than those typically found on the Moon.

Several clusters of these large boulders are strewn across the asteroid's surface. In some areas, the boulders are surrounded by what looks like debris. Is something causing the boulders to disintegrate?

Distinct Boundaries

NEAR images have revealed several areas where sharp boundaries exist between different types of terrain. There is a distinct border between rough, cratered terrain and smooth, almost unblemished areas. Scientists are not sure what caused these sharp boundaries. After all, the asteroid should have been uniformly blanketed by debris from impacts over the millennia.

Collapsing Ground

On the last, closest, and most detailed image of Eros, the *NEAR* cameras revealed an area where the underlying ground appears to have given way, causing the surface to collapse. This feature is only about the size of a hand. Scientists don't know if this type of feature is unique to this one spot or more common around Eros and just too small to be seen until now.

On February 28, 2001, the last signals were received from *NEAR Shoemaker* and the extended mission was brought to a close. Scientists will be studying the data from Eros for years to come.

Melanie Melton is a Web editor for the Society's website, planetary.org.

NEAR Shoemaker Mission Summary

Launched: February 17, 1996
Asteroid Mathilde Encounter: June 27, 1997
Arrival at Asteroid 433 Eros: February 14, 2000
End of Primary Mission: February 12, 2001
End of Extended Mission: February 28, 2001

Eros—Physical Statistics

Size: 33 x 8 x 8 kilometers (20 x 5 x 5 miles)
Mass: 6,700 trillion kilograms (737 trillion tons)
Rotational Rate: 5 hours, 16 minutes (around its shortest axis)
Density: 2,700 kilograms/meters^3 (about the same as Earth's crust)
Largest crater: 5.5 kilometers (3.3 miles)
Largest smooth depression: 10 kilometers (6 miles)

Red Rover Goes to Mars: Student

"It was the best week of my life!" This was the overall sentiment of the Red Rover Goes to Mars Student Scientists after a weeklong visit to San Diego to take pictures of Mars using the Mars Orbiter Camera (MOC) onboard *Mars Global Surveyor* (*MGS*). The students—from India, Hungary, Poland, Taiwan, Brazil, and the United States—earned this unprecedented opportunity through The Planetary Society's Red Rover Goes to Mars Student Scientist | essay contest.

The nine contest winners, aged 10 to 16, spent several days working at Malin Space Science Systems (MSSS), the company that built and operates the MOC. There they worked directly with renowned planetary scientists Ken Edgett and Mike Malin to program the spacecraft camera to capture high-resolution images of specific areas on Mars. Consequently, the Student Scientists made history, as never before had members of the public commanded an instrument on a NASA planetary exploration mission.

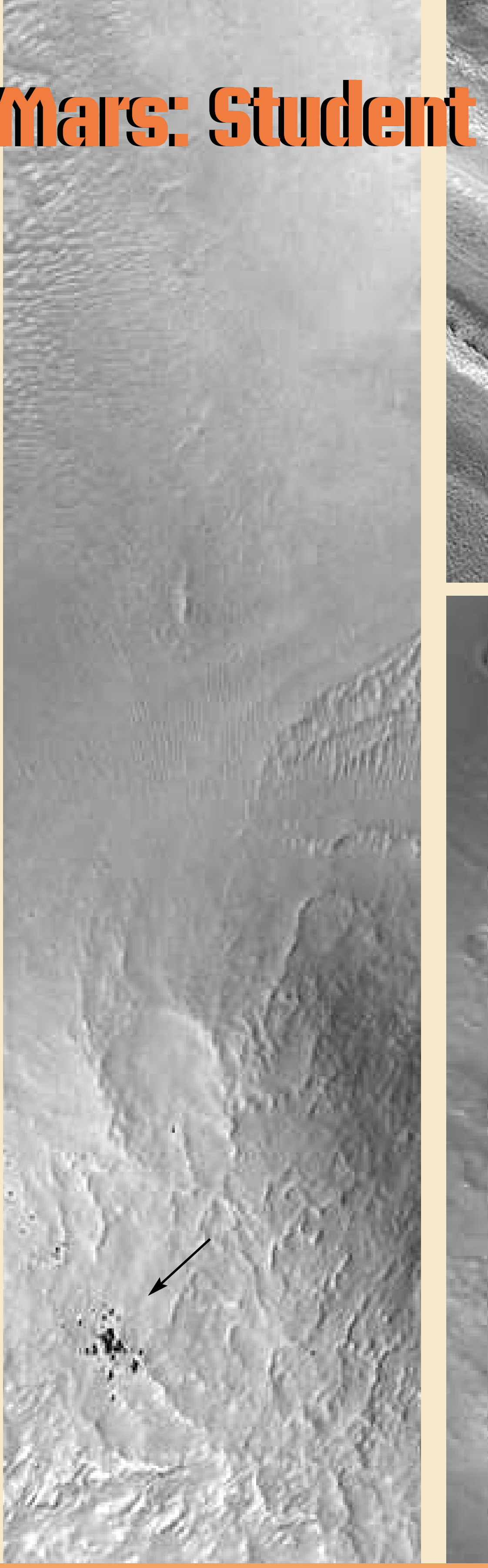
Teamwork

Kimberly DeRose, Shaleen Harlalka, Hsin-Liu Kao, Iuri Jasper, Tanmay Khirwadkar, Zsofia Bodo, Vikas Sarangadhara, Bernadett Gaal, and Wojciech Lukasik trained for their MSSS visit for nearly nine months, studying landing-site training materials and working remotely with experts from the Planetary Science Institute and Planetary Society staff. By the end of their training, the students had a solid understanding of the geology and geography of Mars, the goals of a sample return mission, and the importance of remote-sensing imagery for future Mars landers.

At MSSS, the Student Scientists worked as a team to select three sites to image. Initially they chose a wide range of geological features, including crater rims, slopes, valleys, canyons, polar layered terrain, and chaotic terrain. Then, based on their knowledge of the various regions of Mars and their desire to image different types of landforms, they narrowed their selection to three sites. "It was remarkable how quickly the students began to interact as a team—they overcame language barriers to share their knowledge of Mars, ideas for rover landing locations, and mission objectives," said Rebecca Williams of MSSS. "Their enthusiasm and dedication illustrate the promise for the future of space exploration."

In the end, the student team chose to take high-resolution images of areas in the equatorial, mid-northern latitude, and northern polar regions of Mars. These regions were selected for their likelihood of harboring scientifically interesting features and their potential to reveal some of Mars' mysteries. The staff at MSSS programmed the MOC to image the selected locations when *MGS*'s orbit passed over the targets 48 hours later. After the images were taken, a numerical data representation of each was transmitted from *MGS* to the Deep Space Network (DSN) antenna receiver in Goldstone, California. The students watched as the numerical data were downloaded from the DSN, translated by MSSS software, and converted into digital images, making them among the first people in the world to view these new pictures of Mars.

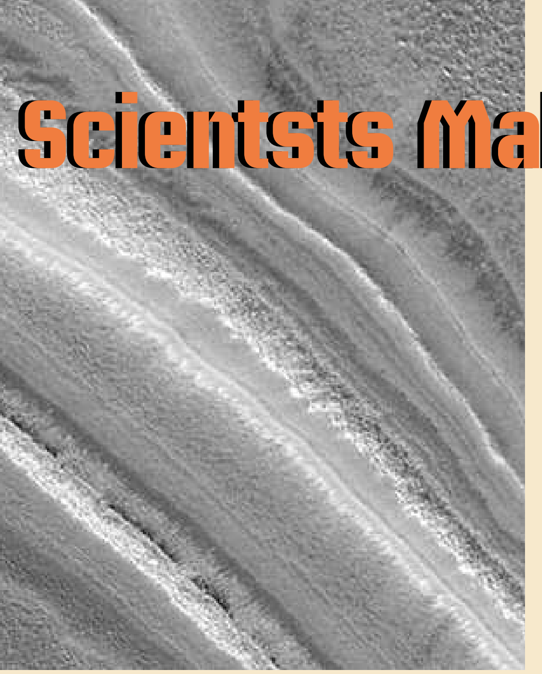
The first image captured alluvial fans in Mars' equatorial region. An alluvial fan—a fan-shaped mass of loose rock material deposited where a stream's velocity decreases suddenly or where a valley widens abruptly—is viewed as a sign of past water on Mars. The second image, of polar layered terrain, is especially stunning, and the students chose it to show the public at a press conference scheduled for the end of the week. The third image, of fretted terrain, displayed another of Mars' mysteries. Amid the dunes and valleys the students expected to find was an unusual grouping of large dark-colored boulders surrounded by light-colored terrain. Where did the boulders come from? And why did they end up clustered together? The image



The Red Rover Goes to Mars Student Scientist team discovered a new Martian mystery hidden in the planet's middle latitudes, near 31 north latitude, 290 west longitude. Amid the dunes and valleys in this region, a puzzling group of dark boulders (see arrow at bottom left) was observed for the first time. What makes this grouping a mystery is the lack of clear clues as to how the boulders got there—and some loom as large as 25 meters. This high-resolution image covers an area approximately 3 kilometers (1.9 miles) wide.

Scientsts Make History

by Rachel Zimmerman



raised many questions but offered no clear explanations. Even professional planetary geologists were stumped. "I looked at a few pictures around [the area] and couldn't find anything to explain it. Very puzzling!" remarked Michael Carr of the US Geological Survey. "These are huge boulders. There are no indications of any outcrops that could shed such boulders."

Meeting the Press

The students released the three new views of Mars at a press conference held at LEGOLAND, a Red Rover Goes to Mars project sponsor. When viewed together as a triptych, the images showcase the diversity, beauty, and mystery of the Red Planet. CNN, MSNBC, Spaceflight Now, and Mars News were on hand to report the event. In addition to journalists, students from the San Diego area attended the press conference, and many of them eagerly sought autographs from their new heroes, the Student Scientist team.

Throughout the week, the students gave presentations at LEGOLAND, where they interacted with park patrons as well as students from local schools. Joining the Student Scientists at LEGOLAND were planetary scientists Matt Golombek and Bob Anderson of the Jet Propulsion Laboratory (JPL), Bill Nye the Science Guy, and Ken Edgett of MSSS. Shoulder to shoulder with the experts, the Student Scientist team fielded difficult questions about Mars with the confidence of professionals.

In addition to their work at MSSS and their public appearances at LEGOLAND, the students spent one morning in Hollywood at Paramount Studios on the set of *Star Trek: Voyager*. Robert Picardo, the holographic doctor on the show and a spokesperson for Red Rover Goes to Mars, gave the students a VIP tour of the set. As part of their special tour, the students had the rare opportunity to see part of an episode being filmed. In addition, they had their pictures taken with members of the *Star Trek: Voyager* crew.

Later that afternoon, the students were taken to Pasadena for a VIP tour of JPL. There they viewed the 25-foot (7.6-meter) Space Simulator, where spacecraft are tested, and the Mars Yard, a sandy and rocky terrain used for testing Mars rover prototypes and simulating Mars missions. Additionally, the students heard special presentations about the *Rocky 7* rover, the FIDO rover, and the nanorover that is currently in development at JPL. Visiting JPL enabled the students to get a perspective on the strong heritage of the NASA Mars Program and its plans to continue innovation and exploration into the future.

All of the Student Scientists have received national media attention and recognition for their participation in the Red Rover Goes to Mars program. The students are now accustomed to appearing on television, in newspapers and magazines, and even in parades. They have become heroes to the other students in their countries, showing that with sufficient interest and effort, young people can make significant contributions to the study of other planets.

The Red Rover Goes to Mars Student Scientists are true role models for future scientists and engineers everywhere. This extraordinary project couldn't have happened without you, the members of The Planetary Society, whose support made it all possible. Red Rover Goes to Mars is just one more example of how, together, "We Make It Happen!"

Rachel Zimmerman is Education Projects Coordinator at The Planetary Society.

For brief biographies of the Student Scientists, see the November/December 2000 issue of *The Planetary Report*. Use the Red Rover Goes to Mars link on our website, *planetary.org*, to learn more about Student Scientists' activities and the Red Rover Goes to Mars project.

Top: A close look at an edge of Mars' northern polar ice cap reveals diagonal stripes of layered terrain. Layers like these provide clues to the history of the Red Planet. This type of layering could have been formed by seasonal expansions and contractions. Recent wind activity left jagged streaks brushing upward to the right. This high-resolution image covers an area approximately 3 kilometers (1.9 miles) wide.

Above: The students guided the Mars Orbiter Camera to turn its attention to Mars' equatorial region and captured this image of valley-like formations. Did flowing water cut through these valleys, leaving layers of sediment on the valley floors? We will need even closer observations of this region to determine the processes shaping it. The image covers an area 3 by 9 kilometers (1.9 by 5.6 miles). *Images: NASA/JPL/Malin Space Science Systems*

Mars Odyssey: A Good Day to Launch

by Glenn E. Cunningham

Dateline: April 7, 2001, Cape Canaveral

It felt like a good day to launch. Corny or not, that's just what some of us who have experienced those final, terrifying moments sense before they "light the candle" prior to a successful launch.

The Florida sky was cloudless, the wind was slight, and no major hitches delayed the countdown. Certainly myriad problems had cropped up, as they always seem to in the final few days before a scheduled launch, but these had all been solved, and by the time our bus reached the viewing area reserved for us semi-important folks, the last hours of the countdown were progressing smoothly.

Déjà Vu

This was the fifth time I'd been at The Cape for the launch of a planetary mission I'd worked on in one capacity or another. (Note that it's not just Florida, or the launch site, or the Kennedy Space Center, or the Cape Canaveral Air Force Station—it's The Cape!) The first two times were with *Voyager I* and *Voyager II*, way back in 1977. I was one of several young systems engineers who conducted final tests and solved last-minute prelaunch problems before each spacecraft began its journey to the outer planets.

The third time was in 1992, when I served as Deputy Project Manager for *Mars Observer*. In the months before that launch, we had ridden out Hurricane Andrew, which had showered the spacecraft with dust particles, and had gotten caught in a thunderstorm as we moved the spacecraft to the launch pad. Such circumstances did not bode well for a mission that was to eventually fail, just three days before reaching Mars.

Then—causing some to call us the "Comeback Kids"—we brought *Mars Global Surveyor* (*MGS*) to the launch pad in November 1996 with a mission to replace *Mars Observer*. On the first scheduled launch day for *MGS*, upper-level winds—winds at high altitudes the launch vehicle has to push through—were strong enough to throw the vehicle off course, so the launch was scrubbed mere minutes before liftoff. The next day felt much like today—a good day to launch—and so it was. *MGS*, atop a Delta II rocket (just like the one *Odyssey* straddled today), streaked above the Atlantic, across Africa, and out over the Indian Ocean, where it departed the Earth for its journey to Mars.

An Old Hand

A lot of nostalgia colored my fifth visit to The Cape. *Odyssey* carried one of the last *Mars Observer* science instruments to return to Mars. George Pace, *Odyssey* Project Manager, had been a teammate on both *Mars Observer* and *MGS*. The details of those past missions swam in my mind as we were bused to the viewing site. We drove past the Mission Director's Center, where I had once sat at a console with TV screens and flashing lights, ready to give "the spacecraft is go for launch" call in the final minutes of the countdown, and where I knew George was now, eager to do the same for his mission.

On the way to the site we passed the cavernous hangars where we had prepared those earlier spacecraft for launch. The bus parked beside Hangar F and near a grassy clearing, where we could look down a corridor in the Florida jungle and see the Delta II rocket, a small trail of liquid oxygen vapor from its first-stage tank visible in the light breeze. After assuring us of the rocket's reliability, our host—an engineer from the company that manufactured the Delta II—advised us just in case of a "mishap" to "hightail it into Hangar F without delay." His recommendation didn't rattle me because (as I mentioned) it felt like a good day to launch.

I joined a large group of people also connected with the mission. They included relatives of people who'd worked on the project, members of groups who'd monitored the development of the spacecraft, and educators from around the country who'd just participated in a science education conference.

I felt like an old hand. I knew what I was looking at down that 3-mile (4.8-kilometer)-long corridor. Besides the Delta II rocket, we could see one of the large service towers that normally surrounds the rocket during the weeks of preparation prior to a launch. For their part, some of the first timers didn't know which was the rocket and which the service tower.

"The Spacecraft Is Go"

Another reason I felt this was a good day to launch was that I had trudged out on Cocoa Beach at 6 a.m., before sunrise, to view the rocket. I knew that they planned to roll the service tower away at 4 a.m. and that, if everything were going well, when I hit the beach and looked up the coast, I would see a gleaming white rocket, brilliantly illuminated with spotlights, standing out there on The Cape. Yes! There it was!

Through a public address system at the viewing site we could hear the launch commentator describe the events in the countdown procedure: "bring up the command carrier". . . "lox tank top off complete". . . "there are no weather violations". . . "the range is go". . . and then "the spacecraft is go." Truly, this was going to be a good launch day.

Idle conversation filled the final 10-minute hold period, and then everything happened quickly. "Five, four, three, two, one, we have ignition . . ." White smoke, as well as steam, surrounded the base of the rocket. Then a flare of bright red flame, and the rocket shot up, up, up into the perfect Florida sky. I managed to snap two pictures before the thunderous roar of the rocket's engines reached us.

As Delta II climbed farther into the sky, it was hard to decide whether to take more pictures or simply watch. I felt as much in awe as I had on previous launches. Years of your labor are riding out there on that big white bird.

Then the six burnt-out solid rocket engine cases jettisoned. Up and out over the Atlantic the rocket flew. Thirty-one minutes later, way out of our sight, *Odyssey* separated from the third stage of the Delta II rocket and began its six-month journey to Mars.

It was a good day for a launch, and it was a good launch too!

Glenn E. Cunningham retired from NASA in June 1999, after 33 years working on planetary spacecraft design and flight operations. While at NASA, he served as Project Manager for Mars Surveyor Operations, Mars Global Surveyor*, and the* Mars Observer *Projects, and was Deputy Director of the Mars Exploration Directorate. Since "retirement" Glenn has served as a consultant for a number of commercial and government clients, and he volunteers at The Planetary Society, where he is Project Manager of its Red Rover Goes to Mars project.*

2001 Mars Odyssey *is launched.*

Photo: JPL/NASA

World Watch

by Louis D. Friedman

Washington, DC—After a delay of two months, on April 9 the Bush administration submitted next year's budget to Congress. While spending is slightly higher than proposed by the Clinton administration, the increase is less than the expected rate of inflation, which means the overall budget decreases. Highlights include the following:

- Funding for the International Space Station remains level. It had been projected to decrease, but increases are required for cost overruns and unexpected expenses in assembly and operation.
- The space science budget is increased, although the increase is $450 million less over the next four years than that projected by the Clinton administration. This can be interpreted as due to the space station overruns.
- The robotic exploration of Mars gets a spending increase to enable development of novel initiatives for the 2007 lander mission. A sample return was not mentioned.
- Both the *Pluto-Kuiper Express* and Solar Probe missions are canceled.
- Programs to prepare for a human mission to Mars are on hold, as is the development of the Habitation Module and the Crew Return Vehicle. Without these components, the International Space Station's crew size is limited to three.
- The X-33 single-stage-to-orbit vehicle is canceled, along with the X-34 test vehicle. Full funding is included for the Space Launch Initiative, a program to develop a replacement vehicle for the space shuttle.

The US Congress has begun conducting hearings in response to the administration's budget proposal. As we go to press, we are planning to submit testimony and mount grassroots campaigns to generate support for a Pluto mission (see box on this page) and for the Mars Outpost program (article on page 4) to enhance robotic scientific exploration and so pave the way for human exploration.

Paris—The European Space Agency (ESA) has issued a Call for Ideas directed to the European scientific community. ESA states they are looking for innovative initiatives to promote European leadership in planetary exploration. Thus far, ESA has conducted only one such mission—the epic Halley comet fly-through in 1986.

Currently ESA is developing two planetary exploration missions for launch in 2003: the *Mars Express*, with an orbiter and lander, and *Rosetta*, a comet rendezvous. The Call for Ideas is a welcome addition to world efforts for planetary exploration.

Meanwhile, The Planetary Society is developing advocacy for an initiative regarding Mars Outposts (see page 4)—an issue we believe spans the future of both human and robotic exploration. We submitted a paper to ESA on such outposts, just as we did to the US Bush administration transition team.

Cape Canaveral—As the Delta rocket launched the *Mars Odyssey* orbiter toward its October 20 rendezvous with the Red Planet, the US Mars program got an additional boost from the executive branch. The Bush administration will continue the steady pace of budget increases in the Martian exploration program begun in the Clinton administration following evidence of possible past life on Mars. More than $500 million will be added to the program over the next five years.

The additional funds will enable the fulfillment of an international plan for 2007 and allow development of a novel lander concept called *Scout*. The 2007 Mars opportunity is attracting considerable attention in a program revamped following the loss of US spacecraft in December 1999. A lander originally scheduled to accompany *Odyssey* was canceled because of uncertainties in its design.

Plans for 2007 include a large, highly mobile and sophisticated rover (the aforementioned *Scout*); an airplane; a balloon (or some similar device); a communications orbiter developed by the Italian space agency; a science and technology orbiter developed by France as a precursor to sample return; and *NetLander*, a set of small French landers for seismological and meteorological studies on Mars. At a meeting of the International Mars Exploration Working Group following the *Odyssey* launch, interest was expressed in a Russian offer of launchers for Mars in return for further participation in the international program.

The Planetary Society plans to be represented in 2007 with the inclusion of our microphone on *NetLander* (see page 22).

Louis D. Friedman is Executive Director of The Planetary Society.

Still Fighting for Pluto

The case for Pluto has been well made. If we miss the opportunity in 2004 to take advantage of the last Jupiter gravity assist for the next two decades, we miss the chance to get to Pluto before the probable atmosphere freezes away, as well as the final shot at favorable lighting conditions for another 200 years. Pluto is the only planet not visited by spacecraft—it has never been observed close up. Yet it holds important clues for understanding the origin and evolution of the solar system, as well as of the solar system's comets and small bodies and hence of all the planets, which are significantly influenced by comets and asteroids.

Despite our successful advocacy—twice applied to rescue Pluto from elimination as a NASA program—and congressional intervention to save the mission, funding in the Bush administration's proposed budget is insufficient for a Pluto mission. A competitive process initiated by the previous administration to produce lower-cost, creative proposals may be for naught.

The Bush budget does call for advanced propulsion technology development to enable a future "sprint to Pluto." But this is disingenuous at best. The only "sprint" possible would have to come from technologies not being considered, let alone funded—nuclear propulsion or super-large and advanced solar or laser sailing. Also, launching a mission to arrive before 2020, as stated in the budget, would directly conflict with plans for a Europa orbiter.

So we continue to argue for a Pluto mission—and ask all our members to join with us. Keep up-to-date on details, strategy, and tactics at our website, *planetary.org*. *—LDF*

Questions and Answers

I have seen photos of the Milky Way that make me wonder: how have we been able to photograph our galaxy if we haven't been able to travel outside it?
—Daniel Alsina,
Hialeah, Florida

The Milky Way galaxy has the shape of a phonograph record—that is, a flat disk of stars, with gas and dust in the vast spaces between those stars. Also, there is a roughly spherical bulge of stars in the middle of the disk, or the galactic center. Most of the Milky Way's stars lie within about 30,000 light-years of the galactic center. Our Sun is located about 25,000 light-years from the center, putting it in the outskirts of the galaxy.

Since our planet is only about 8 light-minutes from the Sun, an observer on or near Earth is essentially looking at the Milky Way from the location of the Sun. If we look at the sky in the plane of the Milky Way's disk, we see the bright band of stars from which the galaxy got its name. This band can easily be observed with the naked eye on a dark night.

If we look toward the central part of the Milky Way, we should see the bulge of stars. However, the visible light from those stars is strongly absorbed by the dust between them, so virtually none of the visible light from stars in the bulge reaches the vicinity of the Sun.

NASA's *Cosmic Background Explorer* (*COBE*) spacecraft carried an instrument called the Diffuse Infrared Background Experiment (DIRBE) that measured light received at infrared wavelengths, which are longer than visible-light wavelengths. Infrared light is much less strongly absorbed by dust than is visible light, so at infrared wavelengths we receive light from all parts of the Milky Way, including the central bulge. Each day *COBE* orbited Earth, it measured light from a large part of the sky (except light too close to the direction of the Sun as seen from Earth). Then those data were used to produce a map each day of that part of the sky.

Over the course of six months, Earth moves halfway around the Sun in its orbit, and in that time *COBE* mapped the entire sky. These data were combined to produce the image of the whole Milky Way as viewed from the vicinity of the Sun. So the picture was not taken from "outside" the galaxy—just from a location in its outskirts (see image below).

This image is so strikingly different from what we see with our eyes because of the ability of infrared light to penetrate the galaxy's entire disk. The complete sky map produced with data from DIRBE shows the Milky Way disk extending all around the sky. In other words, you can see that we are "surrounded" by the Milky Way's disk. The part of the image showing areas opposite the galactic center reveals stars farther out from the center than the Sun (you may see this DIRBE image at *http://space.gsfc.nasa.gov/astro/cobe/ dirbe_image.html*).
—MICHAEL HAUSER,
Space Telescope Science Institute

With all due respect to Jan Oort, I have never understood why astronomers have such confidence in the existence of the Oort cloud. In the absence of any shred of observational evidence, it would seem to me that some level of skepticism is warranted. What's the deal?
—David McGraw,
Montpelier, Vermont

If we calculate the distribution of the original energy of cometary orbits (before they entered our solar system and were perturbed by the planets' gravity), we find a large number of comets with energies corresponding to orbits with semimajor axes greater than 10,000 astronomical units (an astronomical unit, or AU, is 150 million kilometers—93 million miles —or the distance between Earth and the Sun) but still gravitationally bound to the solar system.

The energy of a bound orbit is negative — very negative for small orbits (where the object is deep within the Sun's gravitational potential well and just barely negative) and for big orbits. We find a large number of comets (about a third) where orbital energies are very close to zero, but still negative—corresponding to gravitationally bound elliptical orbits with semimajor axes bigger than 10,000 AU. Energy gives us a

This picture of the Milky Way was created from data captured by NASA's* Cosmic Background Explorer (COBE). *In this infrared image our galaxy's thin disk and central bulge are clearly visible, with stars appearing white and interstellar dust showing as red.

Image: NASA

better parameter for studying the way the comets' orbits are changed by planetary perturbations. The rest of the comets are uniformly spread in energy at smaller semimajor axes.

In 1948, another Dutch astronomer, Adrianus F. van Woerkom, showed that the distribution of comets closer than 10,000 AU results from comets' having orbital energies that are almost uniformly distributed. This is a result of energy changes from passing planets—primarily Jupiter. Comets have random changes in energy due to the random tugs of the planets as they pass through the planetary region.

In 1950, Oort showed that the large number of comets with near zero orbital energies had to come from a distant source—a vast spherical cloud of comets surrounding the solar system at 50,000–150,000 AU (since then the numbers have been revised to something more like 5,000–100,000 AU). Dynamical simulations of the evolution of cometary orbits have shown that there is no other way to get this energy distribution, as well as the very large number of comets at such distances. Oort showed that the flux of comets into the solar system from the cloud could be explained by perturbations from random passing stars. Since then, galactic tides and giant molecular clouds have joined the list of external perturbers.

Even though we cannot "see" the Oort cloud, we can observe its effect on the solar system, i.e., the long-period comets it feeds into the planetary region. We can't see electrons either, but we believe they exist because of the physical phenomena that can be explained by them.
—PAUL R. WEISSMAN,
Jet Propulsion Laboratory

What body in our solar system has the highest sheer cliffs? Is it Miranda? Also, does anyone know the height of these cliffs?
—Ron Sirull,
Pompano Beach, Florida

Vertical scarps (cliffs) are seen on all the terrestrial planets and on some satellites of the solar system. In general, these scarps occur either at the walls of impact craters or at surface faults where upward pressure or downward subsidence (a sinking of the ground with respect to its surroundings) results in vertical slippage of the body's surface materials. We often see evidence of such tectonic activity in the form of large cliffs on opposite sides of fault lines. Mars' Valles Marineris is an example of a large tectonic system in which erosion has accentuated the preexisting surface fissure.

On bodies without atmospheres, however, tectonic features often remain pretty well unaltered since their formation. Such is the case for the large tectonic features near the center of the Uranus-facing hemisphere of Miranda. While Miranda's cliffs at this location are not quite vertical, they certainly have the largest offsets seen in the solar system. Those offsets represent vertical altitude differences of about 15 kilometers (9 miles). In Miranda's low-gravity environment, rocks launched horizontally from the tops of those cliffs could take as long as 10 minutes to reach their base!
—ELLIS D. MINER,
Jet Propulsion Laboratory

Factinos

A team of scientists led by Henry Throop of the Southwest Research Institute in Boulder, Colorado has identified tiny dust specks growing into planet precursors in the Orion nebula and, in addition, has found conditions there that favor the development of Earth- and Mars-size planets rather than gas giants. By pointing the Hubble Space Telescope at a giant dust disk called 114-426, in front of Orion, the team was able to infer the size of particles within the disk by observing how light filtered through its edges.

Although scientists consider the Orion nebula to be a stellar nursery, radiation from extremely bright young stars there acts like a blowtorch on disks where planets could form. However, Throop's team found evidence of dust grains that could evolve into smaller, rocky planets. "We've never seen dust in astrophysics that behaves like this," he said. "It's not direct visual evidence of planets, but it's very direct evidence for large grains, which means these things are sticking together and growing and on their way to becoming planetesimals and planets." A report detailing the team's results was published in the April 27, 2001 issue of *Science*. Alan Boss, a specialist in planetary formation at the Carnegie Institution in Washington, DC said these new findings are encouraging, though they don't explain the whole story of how a dust grain turns into a planet. "There is still a long way to go from 5 microns to 5,000 kilometers," he said, "but it is a start."
—from SPACE.com

Last winter, joint observations of Io by *Galileo* and *Cassini* revealed a towering, never-before-seen volcanic plume. Combined information from the two spacecraft indicates the new plume is about the same size—nearly 400 kilometers (250 miles) high—as that from the Pele volcano.

The recently discovered plume originates from a volcanic feature named Tvashtar Catena near Io's north pole. Alfred McEwen of the University of Arizona said scientists were astounded to discover so large a plume so near the pole, because all active plumes previously detected on Io have been over equatorial regions and no others have approached Pele's in size. If the Tvashtar plume remains until August, *Galileo* may pass right through that area at an altitude of 360 kilometers (224 miles). The plume is tenuous enough to present little risk to the spacecraft, and passing through it could provide researchers an opportunity to analyze its makeup, said JPL's Torrence Johnson, *Galileo* project scientist.
—from the Jet Propulsion Laboratory

Eleven more new planets have been discovered around other stars, reports an international team of scientists from Switzerland's Geneva Observatory and other research institutes. This latest clutch of exoplanets, announced in early April, has a wide range of masses—some bodies are less massive than the planet Jupiter, while others are more than 10 Jupiter masses. These new detections were made by measuring velocity changes of the stars using the Swiss 1.2-meter telescope at the European Southern Observatory in La Silla, Chile, as well as telescopes at the Haute-Provence Observatory in France and the Keck Telescope on Mauna Kea, Hawaii.

Some of the more unusual discoveries include a planet with the most elongated orbit seen so far, moving between 5 and 127 million kilometers (3 and 80 million miles) from its star HD 74156, and a giant planet whose orbit around its Sun-like star is very similar to that of Earth and whose potential satellites might, theoretically, be hospitable to life. Another bizarre find is a planet in a system of three stars where two of the stars move as a very close pair and the third, more distant star orbits this pair. The new discoveries up the grand total of currently known exoplanets to 67.
—from the European Southern Observatory

Society News

Mars Microphone Has New Ticket to Ride

The Planetary Society's Mars Microphone will hitch a new ride to the Red Planet on board the Centre National d'Études Spatiales (CNES) *NetLander* mission in 2007. (CNES is the national space agency of France.) *NetLander* will deploy four landers on the surface of Mars and network them to study the geology, atmosphere, and deep interior of Mars.

Originally launched on NASA's *Mars Polar Lander* in 1999, the Mars Microphone was, unfortunately, lost with that mission when the spacecraft never regained contact with Earth following its descent to the planet's surface.

The instrument, developed for The Planetary Society by the University of California at Berkeley's Space Sciences Laboratory, is designed to record whatever sounds there are on Mars, such as wind, dust, and electrical discharges in the Martian atmosphere, as well as noises of the spacecraft itself. The microphone can be triggered randomly by naturally occurring sounds or it can be programmed to listen to specific lander actions.

The UC Berkeley team of Janet Luhmann, Dave Curtis, and Greg Delory is responsible for the Mars Microphone. Delory gave special briefings about the instrument at a *NetLander* meeting in Nantes, France, April 2–5, 2001.

—Susan Lendroth, Manager of Events and Communications

The Society Supports Under African Skies Program

The Planetary Society is proud to support the Under African Skies program, bringing space education to students in Africa. The Society is providing a grant to help fund 10 graduate students from the US, United Kingdom, Croatia, Malaysia, Burundi, and Nigeria. These students will travel from Johannesburg, South Africa to Nairobi, Kenya, teaching about space exploration, the search for life in the universe, and the benefits of space technology to developing nations. The Under African Skies program also will donate space-related books to school libraries in Africa.

Additionally, in conjunction with the total solar eclipse on June 21, 2001, Under African Skies will host a public conference in Lusaka, Zambia.

For more information about the Under African Skies program or to donate books to the project, e-mail Rachel at *rachel.zimmerman@planetary.org*, or call her at (626) 793-5100, extension 231.

—Rachel Zimmerman, Education Projects Coordinator

Planetary Society to Participate in Japan Open House

The Planetary Society will join forces with The Planetary Society of Japan and the Young Astronaut Council of Japan in an exhibit booth at Japan's Institute of Space and Astronautical Science (ISAS) Open House on August 25, 2001. This annual event draws 20,000 or more people to the ISAS facilities in Sagamihara to view a large array of exhibits on Japanese space science and technology.

The shared booth will showcase projects that involve all three organizations, including the Planetary Society's International Art Competition, Red Rover, Red Rover project, and SETI@ home. In attendance will be Society President Bruce Murray.

For more information, check the Society's website at *planetary.org* or The Planetary Society of Japan's website at *www.planetary.or.jp/en/*, or contact Susan Lendroth at (626) 793-5100, extension 237. *—SL*

Two New Expeditions for Society Members:

• Heritage of Olde England, July 7–19, 2001

Discover the fascinating heritage of Olde England. Explore medieval streets, castles, and cathedrals; historic cities from Canterbury to Bath; and the important Neolithic archaeological sites of Stonehenge and Avebury. Prepare to walk in the footsteps of English astronomers, authors, and scientists who set the stage for advancements we know today.

View Greenwich Observatory, Cambridge laboratories and colleges, and Darwin's home, study, and gardens. Visit private homes, manor houses, and Shakespeare's New Globe Theatre. Stroll through an old Roman market town that now showcases a lovely Georgian townscape. Walk along beaches yielding fossil finds; see the White Cliffs of Dover overlooking the English Channel. Tour Bath's picturesque residential areas featuring stately homes, including the Herschel home.

Come join fellow members this summer to sample the rich scientific and cultural heritage of England with affable historian and scientist Ian Stone.

• Costa Rica & Annular Solar Eclipse, December 8–16, 2001

Costa Rica offers an excellent introduction to the fascinating world of tropical ecology, and on this special excursion we will witness the December 14 Annular Solar Eclipse.

Costa Rica has a long and rich history, including a visit by Columbus in 1502. Currently its expansive park system protects over 25 percent of the country. This diverse nation, ranging from sea level to 3,820 meters, harbors 12 distinct life zones with thousands of species of plants and animals. We will sample some of the most scenic and species-rich areas, including Volcan Poas, the Monteverde Cloudforest, Braulio Carillo and the Caribbean lowlands, the Nicoya Peninsula, and Samara Beach.

Samara Beach will provide the site for our observation of the 2001 Annular Eclipse, where the Moon will cover 96.8 percent of the face of the Sun for 3 minutes and 18 seconds. Astronomer Jose Villalobos will join us for the event.

For a complete brochure or to register for either trip, contact Betchart Expeditions at (800) 252-4910 or *BetchartExJohn@earthlink.net.*

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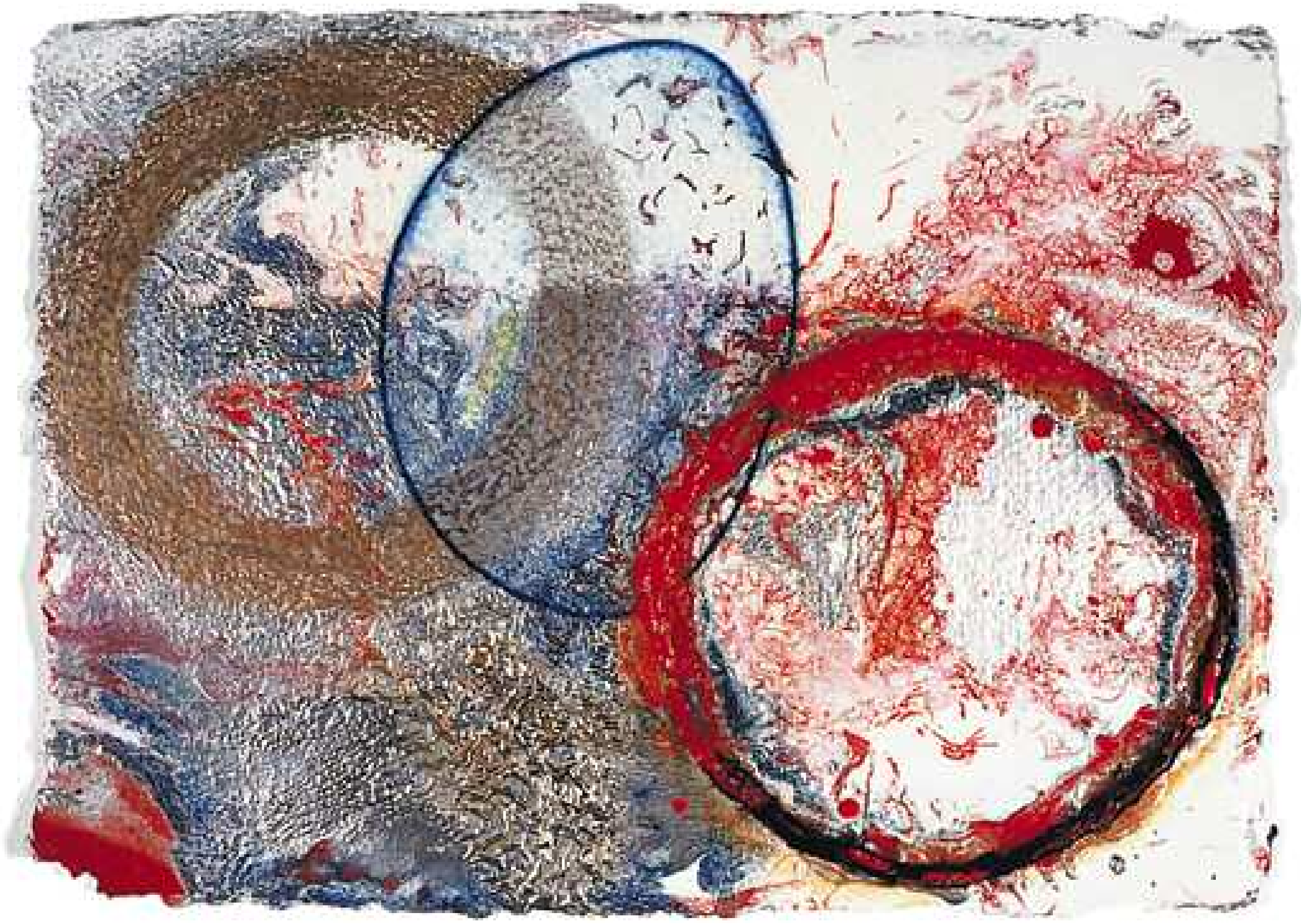

Wanderers, 2000. Aquacryl, Caran D'Ache, One Shot, Deka, silver, and white enamel on handmade paper.

Dorothea Rockburne lives and works in New York City. Some of the many public collections featuring her work include the Whitney Museum of American Art and the Solomon R. Guggenheim Museum in New York, as well as the J. Paul Getty Trust in Los Angeles. Reprinted courtesy of the artist and Lawrence Rubin Van Doren Gallery, New York.

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