The PLANETARY REPORT

Volume XXVI Number 5 September/October 2006

SMART-1 at the Moon

A PUBLICATION OF THE PLANETARY SOCIETY

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From The Editor

The summer of 2006 started off with heat waves blistering the Northern Hemisphere of our planet and closed with one of the most burning disputes in recent popular science, as headlines around the world trumpeted—in print and on computer screens—"Pluto Demoted, No Longer a Planet."

Some people exulted, believing the demotion was long overdue. Others vented their outrage and vowed to fight, while petitions went up across the Internet and schoolchildren wrote letters of protest to the unfeeling scientists who dared to diminish their favorite member of the solar system.

Has the arcane assignment of scientific nomenclature to natural objects ever before sparked a firestorm? I can't think of another instance, although I admit my limited knowledge of scientific and popular history.

Whether or not you agree with the International Astronomical Union's decision that Pluto is not a bona fide planet, you can't deny that the debate is good for space exploration. To see sane people grow immoderately passionate over the scientific term for a ball of rock and ice demonstrates how deeply they can care about worlds they cannot see, except through the telescopes and spacecraft built to explore the universe around us.

It's up to us in The Planetary Society to build this passion into commitment to explore the worlds around us—including Pluto, planet or not.

—*Charlene M. Anderson*

On the Cover:

SMART-1, Europe's first mission to the Moon, is a success! Designed to test technologies, such as deep space electric propulsion, for future interplanetary missions (the spacecraft reached the Moon using only 60 liters, or just under 16 gallons, of fuel), *SMART-1* is a sparkling example of international cooperation among Europe, the United States, Japan, and India.

Illustration: The European Space Agency (ESA) and AOES Medialab

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Members' **Dialogue**

What Is a Planet?

Here, on the Swedish island where I live, lies a city. It has only 25,000 inhabitants but it is a city, proud of its history. It has walls; it has medieval gates. Its name is Visby and it was founded in the 13th century. There may be villages in this world with more inhabitants, but that does not matter. People decide what body of people we call a city.

Pluto has its city wall, though we call it an atmosphere. It has its three gates we call moons. And it has its Planetary Rights, handed over to it about 80 years ago. People decide what names we give to bodies of mass circling the Sun. Scientific conferences should deal with scientific research.

Calling Pluto a planet—or not—is a matter of taste. For historical reasons, and because of the fact that it has an atmosphere and three moons, Pluto will always remain a planet to me.
—RINDERT BOLT,
Slite, Sweden

The International Astronomical Union's Planet Definition Committee (PDC) had articulated a clear, and far less ambiguous, set of criteria for classifying planetary status. Given the gravity of this issue, I would agree with the PDC that size does matter. So, Pluto and 2003 UB313 [now called Eris and formerly nicknamed Xena] should have the "right stuff," as would Ceres.

The beauty of the PDC's proposed definition was that it furthermore resolved the distinction between moon-planetary systems and double planets. As we venture outward and extend our horizons to other solar systems, this definition would have served admirably.

Of course, no classification system is bulletproof or asteroid-proof. There will always be some shadow of ambiguity. Future explorers of alien worlds will be just as befuddled when crossing the banks of some newly discovered extraterrestrial river . . . or should that be stream . . . no, maybe brook . . . or perhaps creek?
—JOSEPH CIOTTI,
Honolulu, Hawaii

The Debate Continues

Thank you for retaining the metric to imperial measurement conversions in *The Planetary Report*. First, I doubt that the United States will convert fully to metrics in my lifetime. Second, the conversions save me the hassle of pulling out my conversion tables whenever I read the publication. Last, and maybe least, I do not believe the continued use of both metrics and imperial measurements will lead to the destruction of The Planetary Society.

Keep up the good work!
—ERNEST SALAZAR,
Key West, Florida

The issue is not whether you save some space or ink. The issue is continued perpetuation of a measuring system that is absolutely useless. The focus should be on the future, including the younger generations that will be learning from *The Planetary Report*. Do not clutter their minds with useless units of measure.
—DAVID SWEETMAN,
Dyer, Nevada

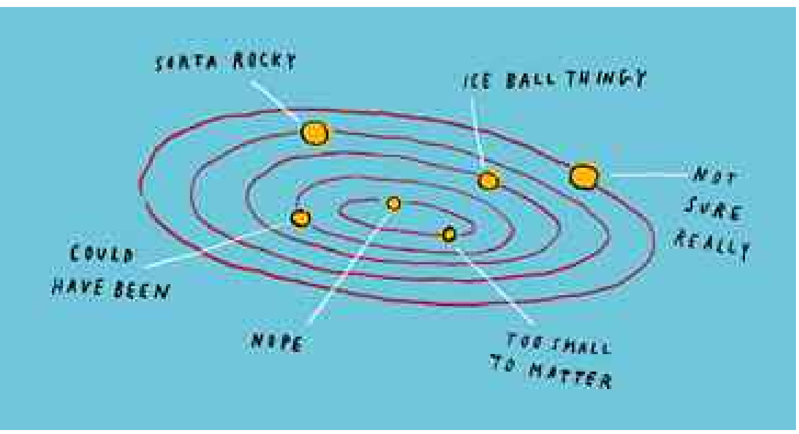

Illustration: © Brian Rea for **The New York Times**

Please send your letters to
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We Make It **Happen!** by Bruce Betts

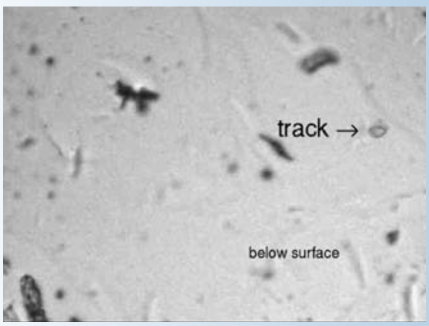
Look for Star Dust from *Stardust*—Stardust@home Goes Live

When NASA's *Stardust* spacecraft returned samples of comet Wild 2 to Earth in January 2006, it also returned interstellar dust. It may sound at first like something you'd want to wipe off with a rag, but this dust is from other stars, the first unaltered such interstellar material ever on Earth.

An estimated 40 or so dust particles were returned in *Stardust*'s aerogel interstellar dust collector. Those few dozen tiny particles will be distributed throughout the collector, causing a cosmic needle in a haystack problem. To aid in the search, scientists have filmed about 700,000 microscope movies of the collector plates. The Planetary Society has been working with Andrew Westphal and his team at the University of California at Berkeley to help with the search through these movies. As it turns out, the solution is you and people like you.

Stardust@home—which is based on The Planetary Society-supported distributed computing success SETI@home —is using people around the world to find interstellar dust. After a very brief web-based training, users with a standard web browser and Internet access can download the movies of *Stardust*'s collector and search for telltale tracks from the particles. I want to extend our special thanks to all those members who helped with the beta testing of the site before the actual data movies were obtained. Your work made a difference!

If you think you have what it takes, or that your kids do, or your dog (OK, maybe not the dog), then find out how to sign up and start reviewing movies at *planetary.org/stardustathome*.



Left: This is approximately what a single image of an interstellar dust track would look like on Stardust@home's virtual microscope. Because no interstellar dust particles have ever been captured, this sample was created in a high energy particle accelerator. Image: Regents of the University of California/Stardust@home

Right: On August 15, 2006, Jake Maule donned the 80-pound spacesuit and explored the red Devonian slopes on the eastern side of Bockfjorden in Spitsbergen. Image: Courtesy Jake Maule

Suiting Up for a Mars Analogue Expedition

We had another last-minute opportunity not only to join an expedition to the Arctic but also to facilitate research into humans and robots working together on Mars. The Arctic Mars Analogue Svalbard Expedition (AMASE) consists of a consortium of scientists and engineers, led by the Carnegie Institute of Washington, who have gone to the Arctic each August for the last few years. They head to the island of Spitsbergen (part of the Svalbard archipelago), which is only 1,000 kilometers (about 600 miles) from the North Pole. The expedition was nearly set for this year when the AMASE team realized it didn't have funding to bring along a spacesuit for some of its testing. Because of the nimbleness of The Planetary Society, we were able to step in quickly to provide a small amount of funding that went a long way.

The Planetary Society cosponsored the expedition by providing funding for a Mark III spacesuit, a style being considered for missions to the Moon and Mars. Jake Maule, a biologist at the Carnegie Institute of Washington, donned the suit at various times during the expedition. He wrote up a log of his activities and also provided amazing pictures that you can find at *planetary.org/explore/topics/planetary_analogs/svalbard _ updates.html*.

Jake explored the world of astronaut-robot interaction on a planetary surface. He worked with the Jet Propulsion Laboratory's "cliff bot," a rover-like device designed to collect samples on steep rock faces. Jake carried out analyses on a sample retrieved by the cliff bot. He also tested science procedures that, although simple for someone not wearing a spacesuit, required careful thought and planning with one. He also worked with other science instruments, including two that are prototypes for instruments that will fly on NASA's *Mars Science Laboratory* in 2009.

The AMASE team also conducted a number of astrobiology experiments to see if a person wearing the spacesuit would transfer any human contamination to the samples. (Spacesuits regularly put out gases and microscopic critters as part of their operation.)

Because of The Planetary Society's ability to step in quickly with needed funding, significant progress was made at this year's AMASE in the areas of human-robotic interaction, understanding contamination of collected samples, and developing and testing procedures for field testing.

Bruce Betts is director of projects at The Planetary Society.

Correction

Last issue, we stated that ESA's *Rosetta* mission would land on comet Wirtanen in 2012. In reality, *Rosetta* will land on comet 67P/Churyumov-Gerasimenko in 2014. Thanks to all of you who caught this error. We apologize for any confusion.

What's **Up?**

In the Sky—October and November

Mercury makes a rare transit of the Sun on November 8. Its tiny disk's five-hour passage in front of the Sun will be fully visible with a properly outfitted amateur telescope from western North America to eastern Australia. Observers in the rest of the Americas and eastern Asia can see part of it near sunset or sunrise. More information can be obtained at *sunearth.gsfc.nasa.gov/eclipse/eclipse.html*. In October, Jupiter is the brightest starlike object in the evening sky low in the west, but by November, it will get too close to the Sun to see. Saturn continues to rise higher in the predawn east.

Random Space Fact

Saturn is the most oblate (flattened) planet in our solar system. Its spin causes it to be 10 percent "fatter" at its equator than at its poles.

Trivia Contest

Our May/June contest winner is William C. Bagley of Webb City, Missouri. Congratulations!

The Question was: What is the longest channel on Venus?

The Answer: Baltis Vallis on Venus is 6,800 kilometers (a little more than 4,000 miles) long.

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

How many of* Apollo 15*'s parachutes worked properly during Earth re-entry?

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

Submissions must be received by December 1, 2006. The winner will be chosen by a random drawing from among all the correct entries received.

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

OUR ADVENTURE WITH JUNO

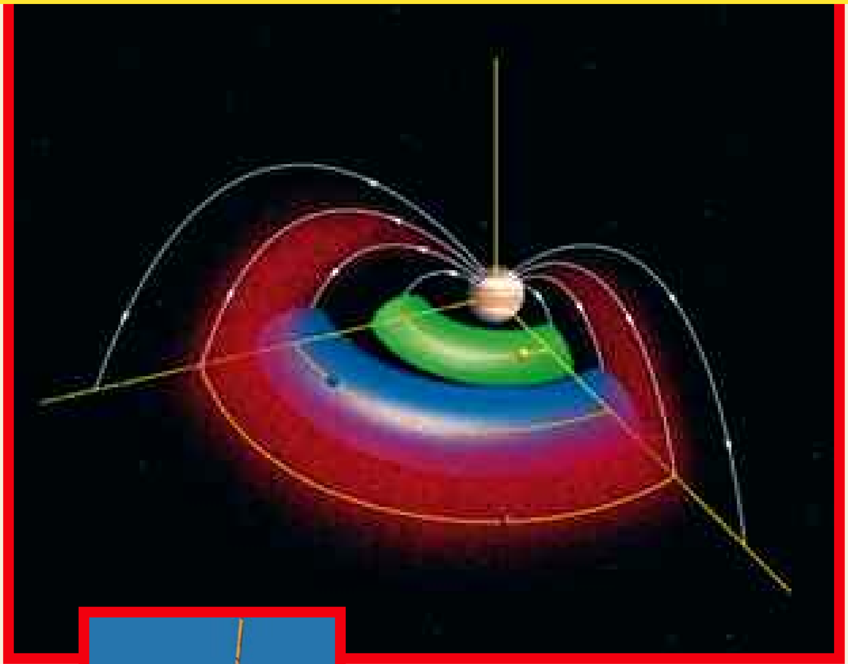
by Dave Stevenson and Ari Berlin

Even with five spacecraft sent to Jupiter—Pioneers 10 and 11, Voyagers 1 and 2, and Galileo—we have probed only the thinnest slice of the planet Jupiter, penetrating with spacecraft hardly deeper than we can see with our own eyes. To answer the arcane question of what lies inside the whirling, solar system–dominating mass, two friends formed an unlikely research partnership. One is an eminent professor at one of the most elite institutions of learning on Earth; the other is a student from a suburban Southern California high school. Below is the story of their collaboration.

Dave: This is a story about a future mission to Jupiter and how I have involved a talented high school student in one small aspect of it. *Juno* is the name of a mission that is part of NASA's New Frontiers program. In Roman mythology, Juno was both wife and sister of the god Jupiter. The current plan is to launch a spacecraft in 2011 and go into orbit around Jupiter in 2016.

You might wonder why we need to send yet another

Left: Although Jupiter and its moons have been visited by several very successful missions, the giant planet itself remains largely unexplored. Now Juno*, a mission that's been in planning stages for years, is slated to launch to Jupiter in 2011, and to arrive there in 2016. Named after the wife (who was also the sister) of the god Jupiter in Roman mythology,* Juno *will delve into the mysteries of Jupiter's atmosphere, water content, core, magnetic field, and magnetosphere, to name a few.*
Image: NASA/JPL



Above: This cutaway schematic of Jupiter's space environment shows elements of Jupiter's magnetosphere, such as magnetically trapped radiation ions (red), the neutral gas torus of the volcanic moon Io (green), and the newly discovered neutral gas torus of the moon Europa (blue). These tori are doughnut-shaped regions of gas particles in the orbits of the moons. The white lines represent magnetic field lines.

Ari Berlin worked with Dave Stevenson on understanding the possible structures of Jupiter's magnetic field and on calculating where the Juno *spacecraft might be during its frequent closest approaches, a few thousand kilometers above the planet's atmosphere.*
Illustration: NASA/JPL

Above: An illustration of the Juno *spacecraft, which is still in its preliminary design phase.* *Images: NASA/JPL*

spacecraft to Jupiter, especially because we had such an immensely successful orbiting mission called *Galileo* just a decade ago. In fact, we have never had a mission that got close in to Jupiter on frequent occasions and figured out what is going on inside. *Juno* will approach to within about 5,000 kilometers (3,000 miles) of the cloud tops on many occasions.

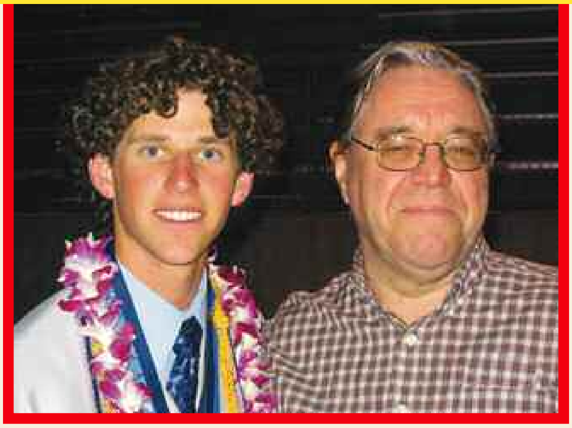
Galileo's greatest success was its revolutionary discoveries about Jupiter's satellites, not the planet itself. It did give us one local snapshot of Jupiter through the probe that dropped into the atmosphere. Still, a lot of what goes on in Jupiter remains mysterious. Does it have a core? How much water is there? Where is the region in which the magnetic field is generated? What is the nature of the strong winds we see in the atmosphere? What about the aurora, the plasma, and the magnetosphere?

The mission has been in planning stages for several years, and we got the go-ahead for the preliminary design phase just a year ago. The person in charge of this mission is Principal Investigator Scott Bolton of Southwest Research Institute. I am a member of the scientific team, principally involved in the gravity and magnetic field aspects. Years ago, I started thinking about what we might learn from a mission like this.

Ari: My name is Ari Berlin. I just graduated from Saugus High School in the Santa Clarita Valley and will be attending Yale University in the fall. I came in contact with Professor Dave Stevenson at Caltech during my freshman year in high school. I guess you could say it all happened by fluke. Through my high school's job-shadowing program, I contacted the Jet Propulsion Laboratory, which in turn led me to investigate the opportunities at Caltech. Actually, it was the age requirement that I couldn't meet at JPL that led me directly to Caltech. And just like that, Professor Stevenson had me come to his office to discuss my interests. That following summer, before entering my sophomore year in high school, I was already working on a science-based project.

It was the summer of 2003, and Professor Stevenson had an idea: to somehow involve me in *Juno*. Although he worked hard to push me to understand the intricacies of *Juno* and the purpose of the mission, I also worked hard to teach myself *Mathematica*—the computer program that I was told would expedite our calculations. In addition to experimenting with the program's numerous functions, with the help of Professor Stevenson, I learned how to generate a du-loop, which is a computational method that continually calculates the next step of a problem based on previous steps. This simple process would subsequently make our project a lot easier.

Dave: I got Ari to calculate possible structures of the magnetic field and what field you might measure out where the *Juno* spacecraft would be during its frequent closest approaches, a few thousand kilometers above the atmosphere. In planets like Earth or Jupiter, the magnetic field comes from an electrical current flowing in the metallic region deep down. In Earth, the core is liquid iron. In Jupiter, it is liquid metallic hydrogen, a material that is created when you squeeze hydrogen to high pressures, about a million atmospheres or more. This material has been made in terrestrial laboratories. The electrical currents are not simple, and the field is therefore not simple either. The "shape" of the field is dominated by a dipole (just as Earth is often said to have a dipole). This is just like the magnetic field of a bar magnet, with a North pole and a South pole. The ways in which the field differs from a dipole tell us about the flows and physical conditions deep down inside.



Ari Berlin and Dave Stevenson on Graduation Day.
Photo: Ellen Berlin

Ari: Although I stayed in close contact with Professor Stevenson over the next couple of years, my summers were occupied at UC Davis with the COSMOS program—the California State Summer School for Mathematics and Science. During the summer of 2004, I was a student in the Mathematics and Engineering Mechanics Cluster, where I furthered my math/science background. After continual involvement with COSMOS that year by participating in science multimedia presentations at events such as the Statewide Advisory Board Meeting at the California Science Center and the Nobel Dinner held at the Getty Center (which Caltech president David Baltimore attended), I returned to COSMOS for the summer of 2005 as a peer mentor intern for Professor Mohamed Hafez in his engineering mechanics classes. Although my summers at COSMOS were focused on engineering, I also spent a considerable amount of time furthering my calculations for the *Juno* project at Caltech that I had started more than two years earlier.

In order to better understand Jupiter's magnetic field and its higher harmonics, I have been attempting to evaluate the field at specified points on the planet and how this field would vary as you followed a field line. Using *Mathematica*, I was able to trace a field line in small increments along the Io flux tube, which is a theoretical field path from the pole of Jupiter to Io (Jupiter's nearest moon). I first plotted the extremely simple case, which is an aligned dipole. I then used the models from some work of Jack Connerney (a scientist at Goddard Space Flight Center who is also involved in the *Juno* mission). Based on his experimental satellite footprints for Io, I plotted the complicated path of a hypothetical field line. The goal of the project is to compare the predictions of rather simple models with the possibly more complicated field geometries that could arise if the winds deep beneath Jupiter's atmosphere create additional observable electrical currents. By comparing the standard model, the proposed modified model, and the likely observations from Juno, it might be possible to decide on the nature of the currents inside the planet. Of course, according to Professor Stevenson, "you won't know if your solutions are correct until you get your Ph.D.!"

Dave: *Juno* will not just measure the magnetic field. It will also measure the gravity field with exquisite precision. And we expect it to answer a puzzle that the *Galileo* probe posed and that figures so centrally in our understanding of the solar system: Where is the water? Jupiter is expected to have a lot of water because oxygen is the most abundant atom in the universe after hydrogen and helium, and water therefore consists of the first and third most abundant elements. Water may constitute as much as a few percent of the total mass of Jupiter. However, the *Galileo* probe found very little water.

Juno will look for water by detecting microwaves emitted from the deep atmosphere. All planets emit microwaves as part of the heat that escapes, but the depth from which these waves can escape depends on the absorbing properties of the molecules. Water is a good microwave absorber (as anyone who has used a microwave oven can attest). Along with determining Jupiter's core, *Juno* will greatly enhance our understanding of how planets form and how our largest planet came to form. This will also improve our understanding of planetary systems in general, and we're now finding lots of those.

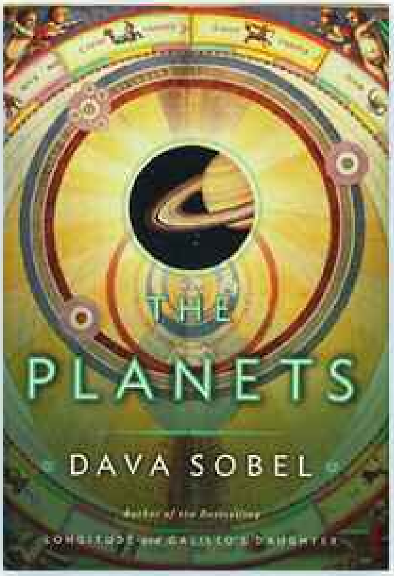
It was fun working with someone as bright as Ari, and we plan to keep collaborating, though perhaps in ways different from this. Missions to the outer solar system take many years from conception to completion, so it seems especially appropriate to involve someone young.

Ari: I came to Professor Stevenson with a clearly defined interest in physics, engineering, and planetary science. Our project has furthered my knowledge in these topics, but I've also become simultaneously more interested in other things, such as politics and government. Our political and other non-science-based discussions combined with our work on the *Juno* project have provided a dynamic and intellectual environment that I'm looking forward to in college and beyond. I want to always participate in science research because it offers an opportunity to delve into something that few have tackled. And that conclusion from the research just might have an astounding affect on the progress of humanity.

It is with utmost sincerity that I plan to bring the influence of scientific research, such as what I've been doing for almost three years, into the political arena. It is my goal to use my supplemental science knowledge to pursue public policies that address more scientific ideas that have otherwise been neglected in the world of politics. I also hope to stay in close contact with Professor Stevenson for years to come. His friendship and influence have been invaluable to my progress as a student and as a person.

Dave Stevenson is the George Van Osdol Professor of Planetary Science at the California Institute of Technology. Ari Berlin is a student starting at Yale this fall.

OUT OF THIS WORLD BOOKS



The Planets
by Dava Sobel
Viking, 254 pp., $24.95, hardcover

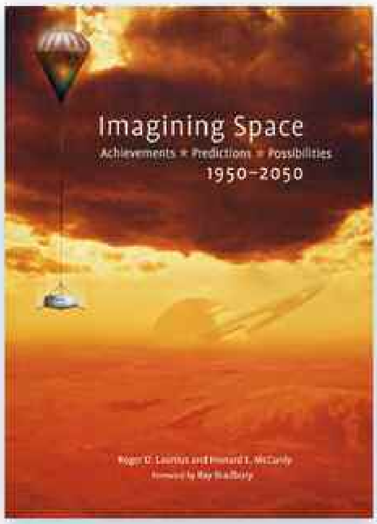
Understanding the family of planets that circle the Sun along with our own world connects to the fundamental human need to know who we are and our relation to the universe. We once explored those wandering lights in the night sky (our word *planet* comes from the Greek for "wanderer") through means such as myth, legend, folk belief, astrology, and fiction. But in the last four centuries—after Copernicus, Galileo, Kepler, and Newton—the planets became provinces of science. In the last four decades, we have begun to explore these other worlds with our mechanical surrogate adventurers.

Science and the other provinces of understanding are sometimes complementary and often competing, but they are all parts of human experience and part of the search for our origins and ourselves. When we formed The Planetary Society a quarter-century ago, Carl Sagan, Bruce Murray, and I hoped to tap this ancient and enduring fascination with the planets, knowing it is why people support the great public ventures to explore other worlds.

In her book *The Planets*, Dava Sobel attempts to capture the ever-changing spectrum through which humanity sees our neighboring worlds. So many aspects of human culture are involved, besides scientific investigation with spacecraft and human explorers, that this could be an overwhelming task. But Dava pulls it off beautifully, interweaving in this little book traditional stories and beliefs with science in chapters about each planet (including Earth's Moon). There is a lot of science in the book, and there is a lot just to enjoy about the wonderful discoveries about our own and other worlds and what those discoveries mean.

Dava is a tremendously gifted science writer, as we know from *Longitude* and *Galileo's Daughter*, and she is an enthusiast of scientific discoveries. Through her words, she allows us to feel almost the same joy as that of the discoverers. Planetary Society members, from professional scientists to young adults, can all enjoy and learn from this book. It would make a greatly appreciated gift for anyone who seeks to know more about those wandering lights in the sky.

—Louis Friedman, Executive Director of The Planetary Society



Imagining Space: Achievements, Predictions, Possibilities 1950–2050
by Roger D. Launius and Howard E. McCurdy
Chronicle Books, 176 pp., $27.00, hardcover

The second half of the 20th century was a period in human history in which we pulled off what many would call our greatest achievement—we became a spacefaring species. In a mere 50-year blip, this huge evolutionary leap advanced from the dreams of science fiction to a reality that is part of our everyday lives. *Imagining Space: Achievements, Predictions, Possibilities 1950–2050* is not only a history of that great leap but also a chronicle of our travels since then and a speculative look at our next steps toward the final frontier.

An inspirational foreword by science fiction luminary Ray Bradbury sets the tone for this book by former NASA historian Roger D. Launius (now at the Smithsonian Institution's Air and Space Museum) and Howard E. McCurdy of American University.

The authors kick off their book in the 1950s, the fledgling days of the space age. Here the work of rocketry and spacecraft pioneers such as Robert Goddard and Wernher von Braun is described alongside that of writers such as Willy Ley and Arthur C. Clarke. This section is generously illustrated with the visionary art of Chesley

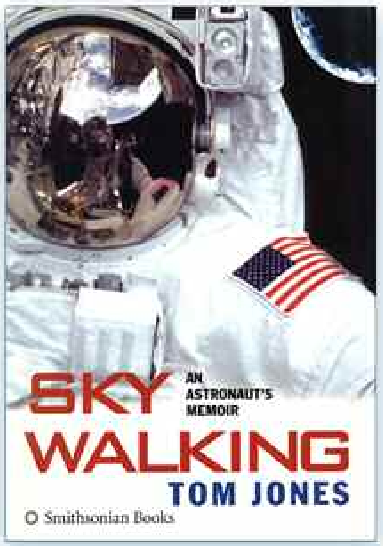
Bonestell, whose paintings of planetary landscapes and futuristic spacecraft are credited with inspiring many a space artist, scientist, and engineer.

Major facets of the modern space program make up the core of the book, with chapters devoted to the search for extraterrestrial life, the lure of Mars, human explorers, and the mechanics of getting off Earth and into space.

The final chapters of *Imagining Space* tackle the question, "Where will we be at the midpoint of the 21st century?" Although practical matters such as the commercial space frontier, the "greening" of space, and even space warfare are discussed, the last chapter, "Understanding the Universe," looks ahead to our travels—telescopic or via spacecraft explorers—out of our planetary neighborhood and into the cosmos, pondering the possible futures that await us out there.

Although *Imagining Space* was published in 2001, it remains a thought-provoking history of humanity's first 50 years as space explorers, earning it a place on every lay space enthusiast's bookshelf.

—Donna Stevens, Associate Editor of The Planetary Report



Sky Walking: An Astronaut's Memoir
by Tom Jones
Smithsonian Books (HarperCollins), 345 pp., $26.95, hardcover

With *Sky Walking*, four-time shuttle astronaut Tom Jones has set the benchmark for giving an inside look at what it is really like to be an astronaut in the shuttle era. His smooth writing pulls the reader in by interleaving technical information with emotional stories.

Jones tells his story in a comfortable way that allows readers to feel that they are there with him. We are with the author as he gets the call that he's been selected as an astronaut, knowing that his and his family's lives will change dramatically. We experience the joy of his first flight assignment, the banter between the astronauts as they awaited liftoff, and the joy mixed with apprehension for him and his family during his first launch. We also learn about each of his four diverse shuttle missions (two that occurred within six months), ranging from radar laboratories, to space walking, to delivering and installing the Destiny module of the International Space Station. We are also there for the lows, including his personal experience of the *Columbia* disaster and his memories of the astronauts who were lost. Throughout the book, Jones shows us not only the "hows" of human spaceflight but also the "whys."

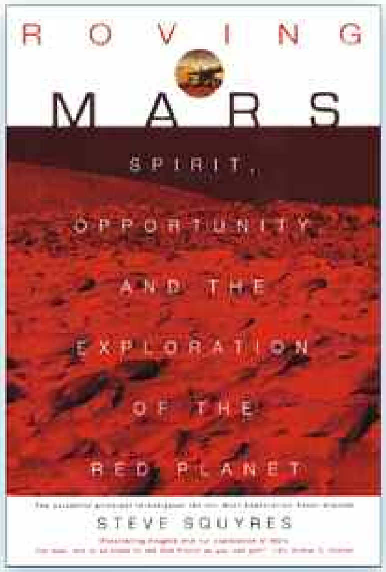
Jones is the only planetary scientist to have been selected as an astronaut. Of course, he had other qualifications for selection, such as being a former B-52 pilot and having worked for the CIA. In addition to chronicling his experiences, he also spends some time in *Sky Walking* discussing the future of human space exploration. He presents his own very thoughtful opinions as well as sharing those of The Planetary Society study in which he participated, one that outlined a possible course for the future. He clearly seeks to inspire and educate, and he now works to move astronauts once again beyond low Earth orbit and out into the solar system.

There can be only a limited number of astronauts and even fewer who will actually fly in space. Those few serve as surrogates for the rest of us. There is little better way to experience what it's really like to hold this privileged position than through this well-told tale of one person's diverse experiences in the astronaut corps.

—Bruce Betts, Planetary Society Director of Projects and Science Editor for The Planetary Report

Roving Mars: Spirit, Opportunity and the Exploration of the Red Planet

by Steve Squyres
Scribe Publications, 434 pp., $25.95, hardcover



Steve Squyres concludes *Roving Mars: Spirit, Opportunity and the Exploration of the Red Planet* with an entry from his journal: September 12, 2004: "There are many things I could wish for our rovers, but in the end, there is only one that matters. What I really want, more than anything else, is boot prints in our wheel tracks at Eagle Crater."

Today, two years later, Squyres' relentless explorers—conceived for a mission to last 90 sols (Mars days) and to drive 600 meters—continue their lengthy journeys, delighting us with a seemingly endless array of Martian finds.

Squyres spins a terrific tale—of science, passion, perseverance, and teamwork. His journal-style entries chronicle now-familiar discoveries with an excitement and awe that come from his front row seat as principal investigator for the Mars Exploration Rover mission (MER). But this remarkable exploration is just one facet of a story that takes us into the heart of the space business, into the life of a scientist and the "family" with which he takes a dream to reality.

He describes years of tough work, rejected proposals, strategizing, personalities, problems and resolutions, unbelievable luck—good and bad—and at last, success that meant a scramble to put this mission together in less than three years. Then, nearly two-thirds of the way through his book, when *Spirit* lands on Mars, Squyres and his team marvel, misty-eyed, at the Pancam's first images.

We read about how, as an undergraduate, he stumbled across *Viking* images in the "Mars Room" of Cornell University and "walked out of the room knowing exactly what I wanted to do with the rest of my life"—as well as the serendipity of *Opportunity*'s astonishing landing in bedrock, with images of hematite that provided the evidence of ancient water on Mars. Throughout, we share his admiration for, and gratitude to, the thousands who worked on the MER project (he lists alphabetically more than 4,000 names in an appendix and apologetically notes that there are likely more), many of whose stories are told in the course of this riveting saga.

Will Steve Squyres get his wish? We certainly hope so. Until then, *Roving Mars* can go a long way in exciting the public to help make it come true.

—*Andrea Carroll, Planetary Society Director of Development*

SMA
EUROPE AT

by Bernard H. Foing

On September 3, 2006 at 7:42 Central European Time (September 2 at 10:42 Pacific Daylight Time) at exactly the predicted time,* SMART-1 *slammed into the Moon, making the Moon's "Lake of Excellence" its final resting place. The carefully choreographed plunge concluded a three-year mission of technology testing and scientific observation. Leading up to the highly anticipated lunar impact, project scientist Bernard Foing came to us to make sure the story of the spacecraft's achievements was not eclipsed by the dramatic ending. Here, he shares some of the highlights of this innovative mission.

SMART-1 *imaged this "slice of the Moon" on November 1*
37,000 miles). It shows a section of the Moon's far side, a
a European spacecraft had seen the lunar far side and w
Experiment (AMIE) camera could take before the spac
Image: ESA/Space

After three years of success, *SMART-1*—Europe's first lunar mission—is coming to an end. With industrial and instrument contributions from the 17 member states of the European Space Agency (ESA), as well as from scientific associates from Europe, the United States, Japan, Russia, China, and India, *SMART-1* is a shining example of international cooperation and is a step toward developing a cohesive international program of lunar exploration.

SMART-1, weighing just 366 kilograms (807 pounds) and fitting into a box about 1 meter in each dimension (excluding its 14-meter solar panels, which were folded during launch), was launched on September 23, 2003 as an auxiliary passenger on an Ariane 5 rocket. It performed a 14-month cruise using the tiny thrust of electric propulsion alone. After its slow but steady journey, *SMART-1* reached lunar capture in November 2004 and went into its lunar science orbit in March 2005.

Throughout the mission—the voyage to the Moon, the six-month nominal mission in lunar orbit, and the one-year extended mission—*SMART-1* has used seven instruments in performing 10 investigations. The instrument suite includes three remote sensing instruments searching out answers to some key planetary scientific questions about the Moon: its origin and evolution; the local and global composition of its crust; its impact, tectonic, and volcanic history; the search for cold traps at the lunar poles; and the mapping of potential lunar resources.

Getting There: Solar Electric Propulsion to the Moon

ESA's *SMART-1* mission was designed specifically to test technologies to be used on future ESA missions. ESA developed the line of SMART (Small Missions for Advanced Research in Technology) missions as demonstrations for deep space electric propulsion and other technologies for future interplanetary missions. For *SMART-1*, this meant demonstrating that electric propulsion is an effective primary means of propulsion as an alternative to conventional chemical propulsion.

Geostationary communications satellites have employed electric propulsion systems for station keeping since the early 1980s, and low Earth orbit satellites, such as the Iridium mobile communications cluster, have also used electric propulsion for orbit adjustments. The use of electric propulsion as a spacecraft's primary means of propulsion is still being tested. NASA's *Deep Space 1*, which was equipped with another type of xenon ion engine, demonstrated electric propulsion for interplanetary navigation after being injected into deep space by chemical means. *SMART-1* went a step further by relying only on electric propulsion to escape Earth orbit and get to the Moon.

Whereas chemical propulsion systems store their energy in the propellants, solar panels generate the energy in electric propulsion systems, meaning that the energy supply is theoretically unlimited. There are, of course, practical limitations. The spacecraft still uses propellant for thrust, and there is a mass limit on how much propellant can be launched with the spacecraft. In addition, launch mass constrains how large the power system can be. The power system mass, in turn, limits the rate at which energy is supplied to the propellant.

Electric propulsion vehicles tend to have low thrust-to-mass ratio (and therefore have low acceleration). Because it is using light as its energy source, however, an electric propulsion system can be used continuously

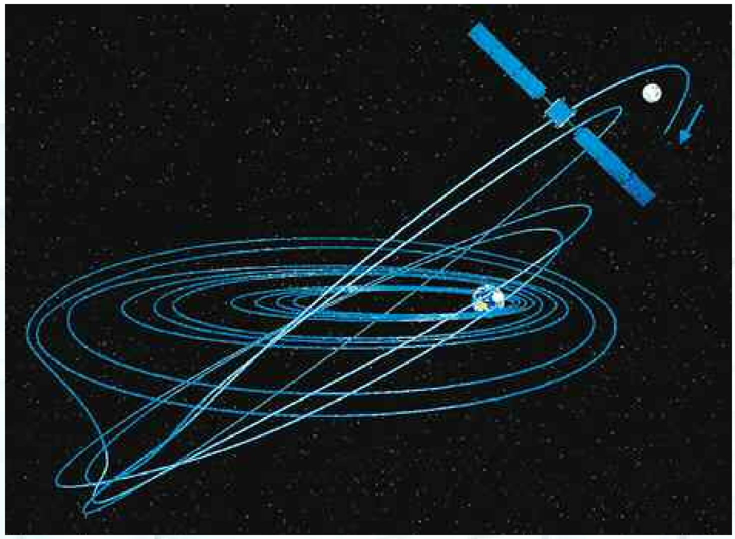
ART-1

THE MOON

2, 2004 from a distance of about 60,000 kilometers (roughly
t about the latitude of the north pole. This was the first time
vas the last shot *SMART-1*'s Advanced Moon micro-Imager
ecraft began its delicate maneuvers to enter lunar orbit.
Exploration Institute

for months or years, whereas a chemical system would be used in periodic "burns" to conserve the propellant.

After being launched into Geostationary Transfer Orbit and spiraling out of the inner radiation belts, *SMART-1* used its solar electric propulsion to carry itself from within the Earth's gravity well to the Moon. This phase lasted 14 months, during which the team calibrated science instruments and checked out the spacecraft before it arrived at the Moon.

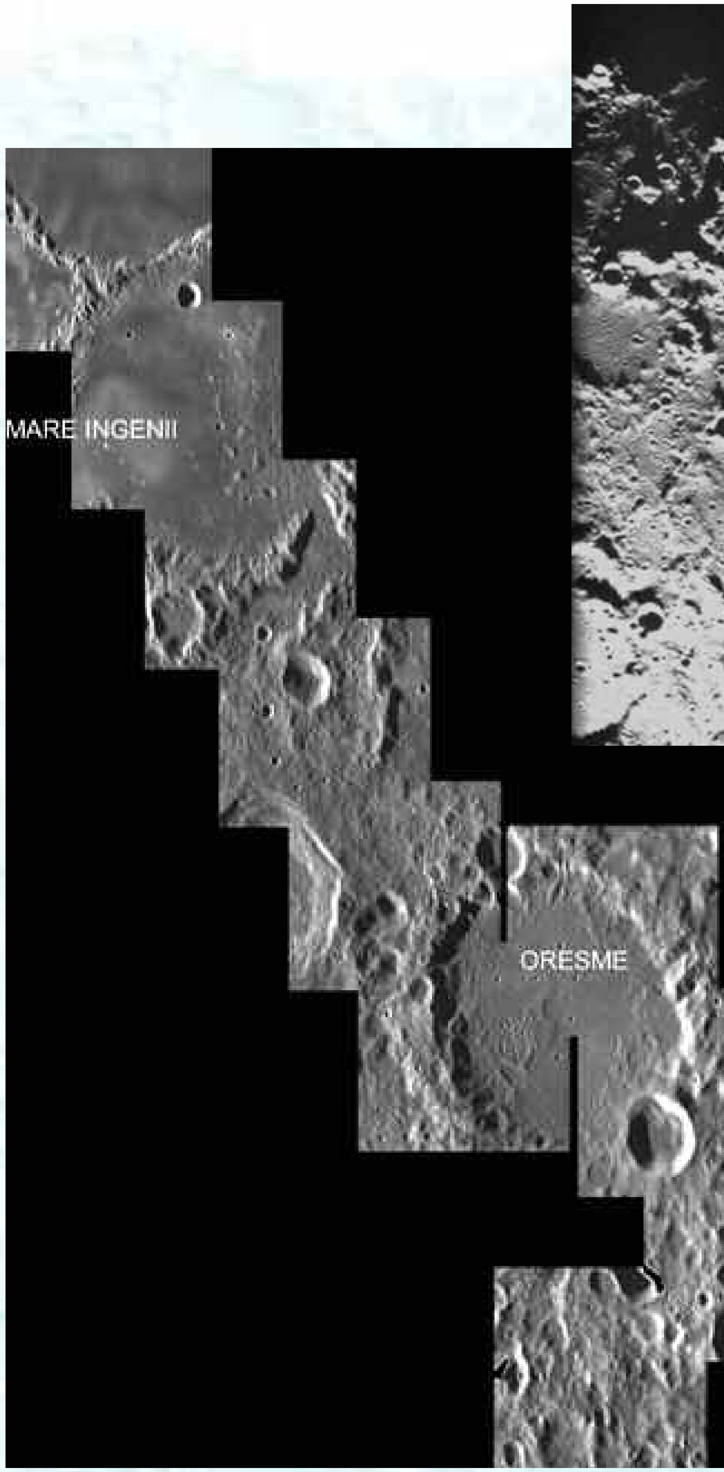


As it departed from Earth and headed for the Moon, SMART-1*'s orbit expanded into ever-increasing ellipses. When the spacecraft reached its destination, its orbit was altered by the Moon's gravitational field. It used a number of these "gravity assist" maneuvers to position itself for entering orbit around the Moon. The* SMART-1 *team checked out the spacecraft's health and calibrated its instruments during its 14-month journey from Earth to the Moon.* Illustration: ESA/AOES Medialab

In November 2004, the spacecraft entered into a polar lunar orbit that was highly elliptical, with an altitude from 5,000 to 51,500 kilometers (3,000 to 30,900 miles). Then, we used electrical propulsion to spiral until March 2005, down to a starting perilune (nearest point to the Moon) at 450 kilometers (270 miles) and an apolune (point farthest from the Moon) lowered from 10,000 to 3,000 kilometers (6,000 to 1,800 miles) to increase the resolution and sensitivity of the science instruments during the lunar mapping phase. The primary mission lasted for six months. In August 2005, spacecraft controllers adjusted the orbit (a maneuver that used all the remaining xenon) to allow an additional one-year mission extension. In the final months of the extended mission, the spacecraft moved closer and closer to the Moon until its foretold impact on September 3, 2006.

SMART-1 Science Instruments

		Mass (kg)	Power (W)
EPDP	Electric Propulsion Diagnostic Package	2.4	18
SPEDE	Spacecraft Potential, Electron and Dust Experiment	0.8	1.8
KATE	Ka-Band TT&C Experiment	6.2	26
D-CIXS	Demo Compact Imaging X-ray Spectrometer	5.2	18
XSM	X-ray Solar Monitor	with D-CIXS	
SIR	*SMART-1* InfraRed Spectrometer	2.3	4.1
AMIE	Advanced Moon micro-Imager Experiment	2.1	9
RSIS	Radio Science Investigations with *SMART-1*	using KATE & AMIE	
Laserlink	Experimental Deep-Space **Laser link**	using AMIE	
OBAN	On-Board Autonomous Navigation Experiment	using AMIE	



Investigating the Moon

We equipped *SMART-1* with seven instruments to perform 10 distinct science and technology investigations. Three instruments studied the spacecraft and the lunar environment: the Electric Propulsion Diagnostic Package (EPDP); the Spacecraft Potential, Electron and Dust Experiment (SPEDE); and the Radio Science Investigations with *SMART-1* (RSIS). EPDP and SPEDE had additional roles of studying the lunar exosphere.

The orbiter also carried three instruments for lunar remote sensing: the Demo Compact Imaging X-ray Spectrometer (D-CIXS) with X-ray Solar Monitor (XSM) for global X-ray mapping; the near infrared mapping spectrometer called the *SMART-1* InfraRed Spectrometer (SIR), and the localized high spatial resolution color imaging camera called the Advanced Moon micro-Imager Experiment (AMIE).

With these instruments, we set out to investigate how rocky planets form and evolve: the origin of our Moon, and what processes—such as impacts, tectonics, volcanism, erosion, and volatiles—shape bodies like the Moon. We also knew our work would help prepare future lunar science and exploration from both orbit and the surface.

SMART-1 got a good look at the Moon. It performed the first global X-ray map (at 50-kilometer, or 30-mile, resolution) of magnesium, aluminum, and silicon. It also created the first infrared spectral mineralogy map and sent back high-resolution (up to 40 meters per pixel) color images of the lunar surface.

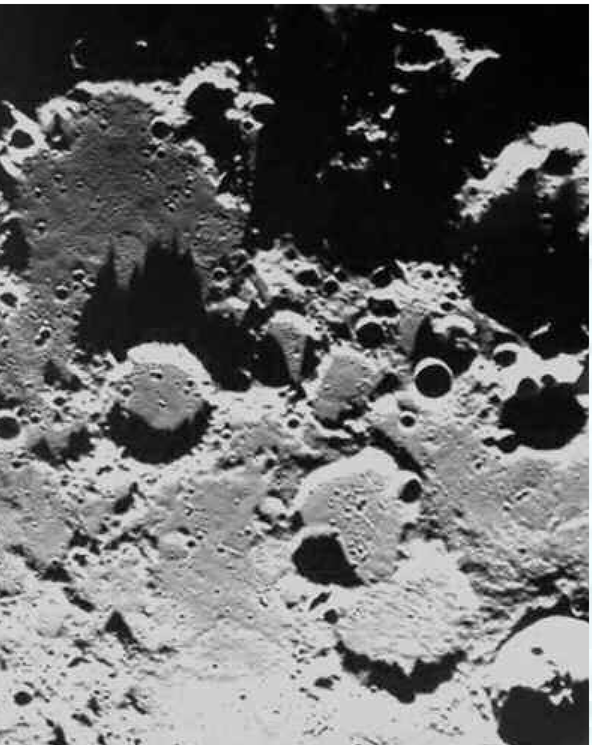
The X-Ray Moon: Tracing Violent Beginnings

X-rays are useful for measuring the amounts of certain elements on the surface. The D-CIXS experiment deployed a new X-ray spectrometer as well as a solar X-ray monitor to examine the crustal composition of the Moon. Data from D-CIXS are being used to produce the first global view of the lunar surface in X-ray fluorescence (XRF), showing the elemental abundances of magnesium, aluminum, and silicon across the whole Moon. *Apollo 15* and *16* performed XRF measurements of the lunar surface, but these measurements covered only 9 percent of the Moon, near the equatorial regions. With *SMART-1*, we're not only seeing more of the composition of the lunar crust, we are also able to detect smaller amounts of key elements. More important, rather than the elemental ratios derived from the *Apollo* measurements, D-CIXS derived absolute elemental abundances by measuring the incident solar spectrum that causes the lunar surface to fluoresce in X-rays and made the first detection of calcium from orbit.

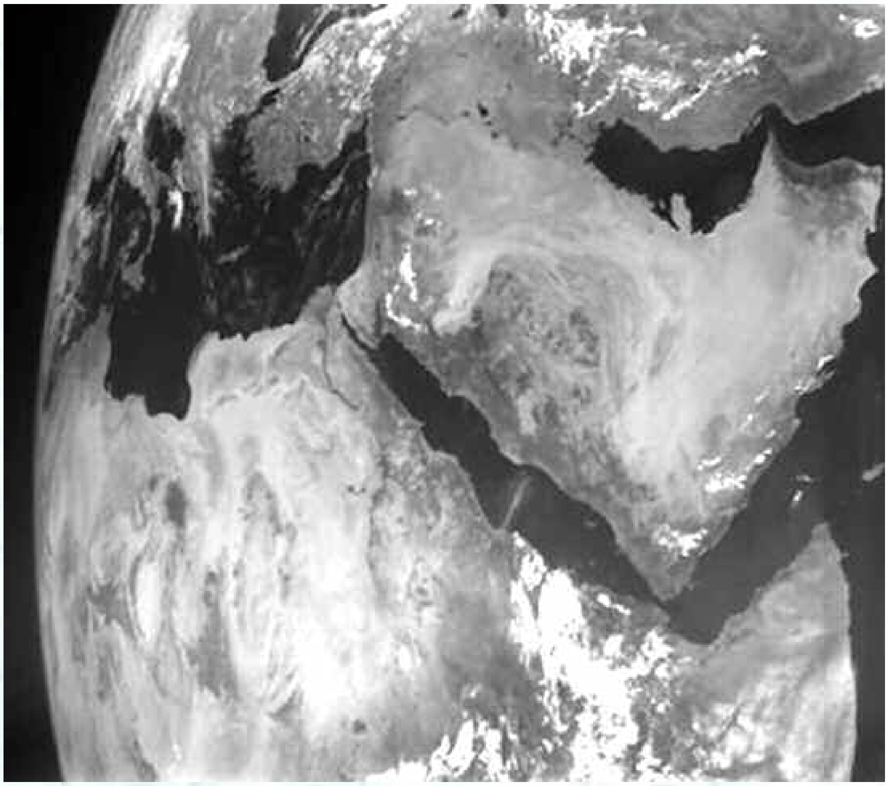
D-CIXS also mapped the South Pole-Aitken Basin (an intriguing site for future exploration) and other large lunar impact basins. D-CIXS data will also help refine the estimates of bulk crustal composition, which has implications for theories of the origin and evolution of the Moon.

The Infrared Moon of Minerals

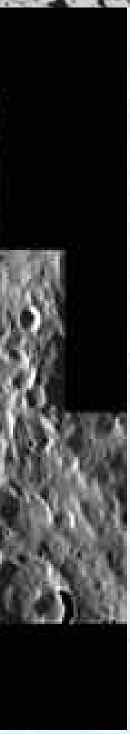
Infrared wavelengths are useful for studying the mineralogy of the surface. With 256 spectral channels over the range of 0.93 to 2.4 micrometers (one micrometer is one millionth of a meter), *SMART-1*'s infrared instrument SIR closely examined the mineral composition across the lunar surface. In addition to mapping the



Above: On December 29, 2004, the AMIE camera took this image of an area 275 square kilometers (99 square miles) in diameter close to the Moon's north pole from an altitude of 5,500 kilometers (about 3,400 miles). This frame, nicknamed by the SMART-1 *team as "peaks of eternal light," shows a heavily cratered highland terrain and is being used to monitor illumination of polar areas as well as long shadows cast by large crater rims. The AMIE camera mapped areas on the Moon that are always lit and others that are always in shadow.*
Image: ESA/Space Exploration Institute



Even before SMART-1 *went into orbit, the AMIE camera began to snap photos. This picture of Earth, taken in July, 2004 , shows parts of Europe, the Mediterranean Sea, the Middle East, and Africa.* *Image: ESA/Space Exploration Institute*



Left: This mosaic is composed of images taken by AMIE on August 30, 2006. It shows an area 400 kilometers (250 miles) long located within the Moon's south polar Aitken Basin. With a diameter of 2,500 kilometers (1,500 miles) and a depth of up to 12 kilometers (7.5 miles), the Aitken Basin is the largest known impact structure in the solar system, and there is a possibility that it excavates through the lunar crust, exposing the mantle material below.
Mosaic: ESA/Space Exploration Institute

lunar surface in the near-infrared, SIR also specifically searched for exposed materials from the lower crust and mantle, central peaks, walls, rims, and ejecta blankets of large impact craters.

SIR has high enough spectral resolution to separate the pyroxene and olivine signatures in lunar soils, which is a key to understanding the evolution of crustal materials. Olivine is considered by many to be a common mineral in the lunar mantle, so its distribution throughout the lunar crust and across the lunar surface is of critical importance to models of crustal differentiation and evolution. A key target for observations using the SIR instrument was the 2,500-kilometer (1,500 mile)-diameter South Pole-Aitken Basin, which exposes stratigraphy of the lunar crust.

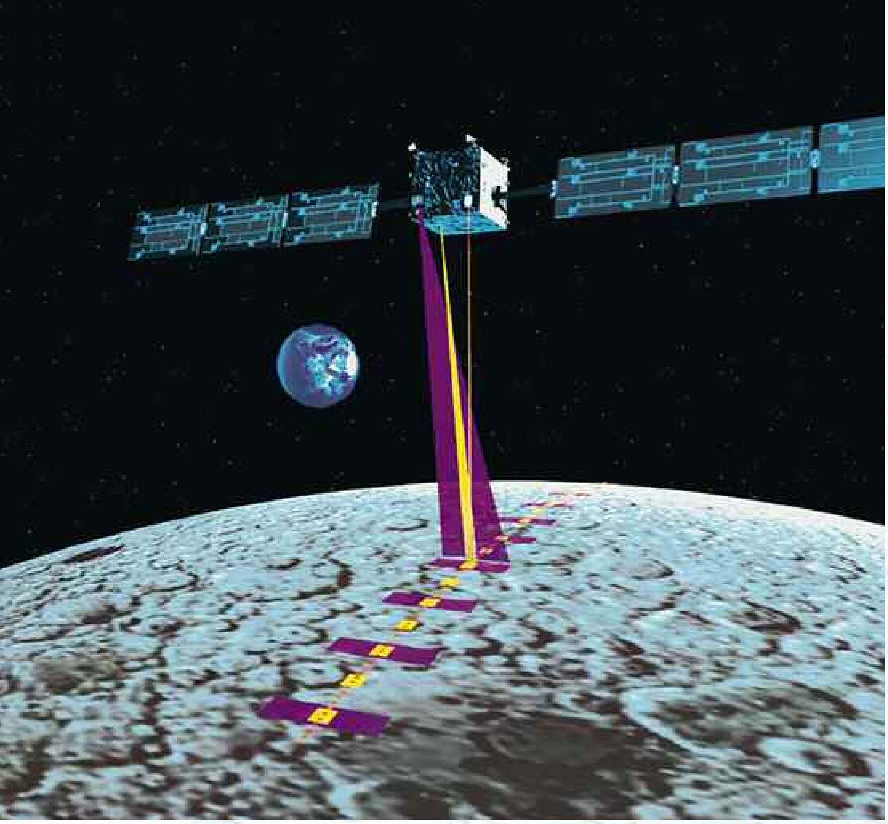
SIR data will also help to refine compositional analyses from earlier *Clementine* and *Lunar Prospector* data. *SMART-1* infrared spectroscopy, with a resolution as good as 300 meters, permits us to study a wide age range of small-diameter craters, which will enhance studies of the influence of space weathering on reflectance spectra.

New Visible Moon Views

The micro camera AMIE provided loads of high-resolution CCD (charge-coupled device) images of selected lunar areas. Even before going into orbit, AMIE was sending back spectacular images of Earth and the Moon. AMIE could observe in white light and through three color filters. The camera's average resolution of 80 meters per pixel improved to just 30 meters per pixel near perilune.

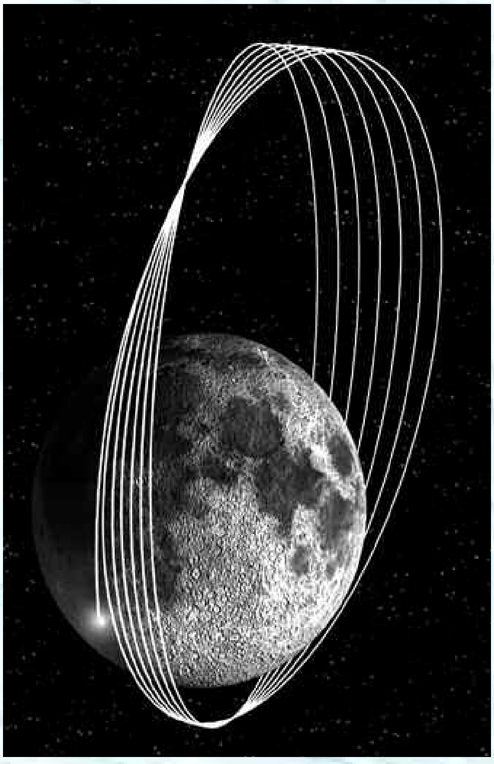
Furthermore, the *SMART-1* target pointing has allowed AMIE and SIR to take nearly continuous measurements with varying phase angle (the Sun-Moon-spacecraft angle: multiple phase angles can allow additional information on the soil roughness to be extracted from the data).

Besides giving us great images to admire, AMIE's work provided a geologic context for SIR and D-CIXS data. Also, through repeated and long-exposure images



SMART-1 ***'s remote sensing instruments scanned the Moon to gather information on its formation and evolution, along with the composition of its crust, as well as to search for cold traps at the poles and to map potential sources of lunar resources.*** *Illustration: ESA/AOES Medialab*

of the lunar south pole, AMIE searched for shadowed or double-shadowed areas—areas indicating potential water ice "traps." Additionally, AMIE mapped locations of "eternal light" and "eternal shadow," potential future landing sites, and other sites that could serve as future lunar bases or resource mines.



In November 2004, **SMART-1** ***entered a highly elliptical orbit around the Moon's poles. The final phase of its mission, including its demise via impact with the lunar surface, is illustrated here.*** *Illustration: C. Carreau, ESA*

Leading an International Lunar Fleet

SMART-1 holds the title of Europe's first lunar mission, but it's also the first of an international fleet of spacecraft preparing to head for the Moon. The *SMART-1* team is working with the teams from these upcoming lunar missions: the Japanese *SELENE* and *Lunar-A* missions, *Chandrayaan-1* of India, the Chinese *Chang'E 1*, and NASA's *Lunar Reconnaissance Orbiter* and *LCROSS* impactor. Together, we will study sites for future landers and rovers, contributing to the development of an international program of lunar exploration

Even though the spacecraft has met its end, *SMART-1*'s X-ray data, along with infrared and imagery data, will be analyzed for months and years to come. *SMART-1* data are archived and will be integrated with existing data from previous missions, such as *Apollo*, *Luna*, *Clementine*, and *Lunar Prospector*. Instruments and techniques tested in examining the Moon from *SMART-1* will later help ESA's *BepiColombo* spacecraft to investigate the planet Mercury.

Like many of its predecessors, *SMART-1* ended its mission through a controlled crash, in this case into the Moon. On September 3, 2006 a coalition of observatories around the globe watched as *SMART-1* plummeted into the Moon's Lake of Excellence, a volcanic plain area surrounded by highlands located at midsouthern latitudes. Even in this final phase of the mission, *SMART-1* brought together the world community in space exploration.

Detailed information and updates on the *SMART-1* mission can be found on the ESA Science Tech Web pages at *http://sci.esa.int/smart-1/* and the ESA public site at *http://www.esa.int/SPECIALS/SMART-1/index.html*.

Bernard H. Foing is SMART-1 *principal project scientist, as well as chief scientist and senior research coordinator in the Research and Scientific Support Department at the European Space Agency.*

Acknowledgments

Thanks are extended to the members of *SMART-1* teams that prepared the spacecraft and various aspects of the mission. We thank in particular R. M. Bonnet, G. D. Racca (ESA project manager), L. Stagnaro, A. Marini and the ESA project team, O. Camino, J. Schoenmakers, R. Blake and the ESOC team, P. Rathsman (Swedish Space Corporation) and the European industrial teams, J. L. Josset, S. Beauvivre, P. Cerroni, P. Pinet, M. Grande, B. Kellett, J. Huovelin, H. U. Keller, A. Nathues, U. Mall, A. Malkki, W. Schmidt, G. Noci, Z. Sodnik, P. McManamon, R. Birkl, L. Iess and associates from the *SMART-1* Science and Technology Working Team (STWT), D. Frew, M. Almeida, J. Volp, M. Sarkharati, E. Evrard and D. Koschny from the ESTEC STOC instrument operation team, P. Ehrenfreund, C. Veillet, D. Wooden, A. Cook, M. Burchell, M. Talevi, J. Landeau-Constantin, B. vonWeyhe, and C. Habfast from the *SMART-1* impact campaign team.

SMART-1's Grand Finale

When a spacecraft orbits the Moon, it is doomed by the law of gravity. Tugs from the Sun, Earth, and irregularities in the Moon itself all disturb its orbit. Sooner or later, any lunar orbiter will impact the Moon's surface unless it has enough fuel to be boosted and escape the lunar gravity.

After its long cruise, six-month primary mission, and additional year of extended mission, *SMART-1* had no leftover xenon fuel. If left on the course of its lunar orbit, *SMART-1* would have naturally hit the far side of the Moon on August 17, 2006. Because I wanted the opportunity for scientists and the public to observe the impact, I proposed to use the hydrazine from the attitude thrusters, and the spacecraft control team at the European Space Operations Centre (ESOC) in Darmstadt, Germany performed a two-week series of maneuvers at the end of June to tweak the orbit of *SMART-1* so it would impact the near side.

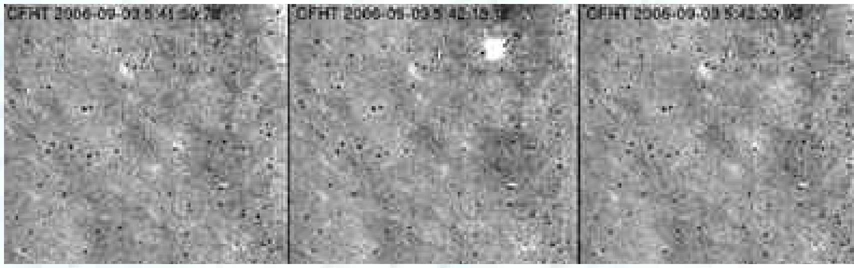
The choice to crash on September 3 allowed ground telescopes to see the impact from Earth, and, as a bonus, the spacecraft had more time to capture high-resolution images from orbit.

The spacecraft impacted an area called the Lake of Excellence. At the time of impact, this area was in the dark, just near the terminator (the line separating the lunar day from the lunar night)—a purposely chosen area that would be shadowed from the Sun's direct rays but faintly lit by Earthshine.

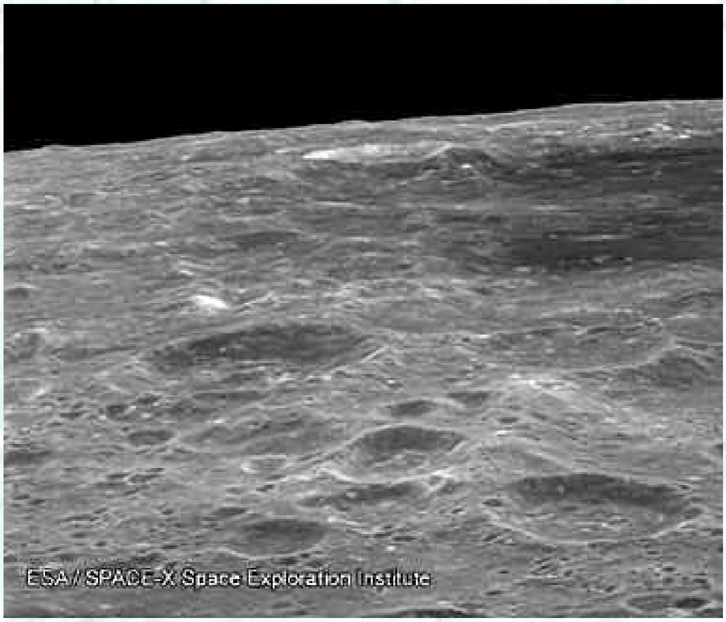
The spacecraft's orbit took it over the Lake of Excellence region every five hours, getting one kilometer lower with each pass. Because the region has varied topography—a volcanic plain surrounded by highlands—we found it difficult to predict accurately when the impact would occur. The hoped-for time of impact was set for 7:42 Central European Standard Time (CEST), but the team was prepared for a possible impact up to five hours earlier that might occur as the result of an unexpected hill. Based on the latest stereo topography and on AMIE images taken on August 19, we found that a crater rim could create a premature impact, so we performed a final hydrazine maneuver on the morning of September 2 to raise the perilune by 600 meters. In the end, *SMART-1* was right on time, and the operations center received its last articulated word at 7:42:21.7 CEST. Radio observatories monitored the signal until impact.

In Europe, the Moon had already set, but observers in the west end of the Americas and in Hawaii, at NASA's Infrared Telescope Facility and the Canada-France-Hawaii Telescope (CFHT), and at Japan's Subaru Auxiliary Telescope, searched for evidence of the impact. We had a live event at ESA's Space Operations Centre in Darmstadt following the last moments of *SMART-1*. CFHT reported in real time that they detected the flash and later reported a postimpact cloud from the analysis.

During its final orbits, *SMART-1*'s camera captured some oblique views of areas that we have previously looked at only vertically, providing a sort of three-dimensional view of the surface.



Left to its natural course,* SMART-1 *would have crashed into the far side of the Moon on August 17, 2006. Because scientists wanted to see the impact, mission controllers tweaked the spacecraft's orbit so that it would hit the near side instead. The spacecraft ended its mission exactly as planned by crashing into the Moon's Lake of Excellence, and this sequence of* SMART-1 *impact images was captured by the 3.6-meter optical/infrared Canada-France-Hawaii Telescope (CFHT) in Hawaii. The impact flash lasted only about 1 millisecond. It may have been caused by the thermal emission from the impact itself or by the release of spacecraft volatiles, such as the small amount of hydrazine fuel remaining on board. Images: Canada-France-Hawaii-Telescope Corporation



By delaying* SMART-1*'s mission-ending crash to September 3, 2006 (Central European Time), the team was able to capture more high-resolution images from orbit. This oblique view of the lunar surface was taken on September 2, 2006 by AMIE during its final orbits before impact, and it presents a view of the surface previously seen only from a vertical position.
Image: ESA/Space Exploration Institute

SMART-1 was traveling at about two kilometers per second (4,500 miles per hour) when it hit the Moon. As fast as that sounds, it is much slower than a natural meteoroid. Although we don't know for sure yet how large the crater made by *SMART-1* is, it was expected to be from 3 to 10 meters wide and perhaps a meter deep. To put that in perspective, the Moon already has hundreds of billions of craters as big as *SMART-1*'s, and every day, several small meteoroids add new ones. *—BHF*

World Watch

by Louis D. Friedman

Washington, D.C.—There was upheaval on the top-level NASA Advisory Council (NAC) when Administrator Michael Griffin asked for the resignations of Wesley T. Huntress, Jr. and Eugene Levy, both members of the NAC Science Committee. Then, Charles Kennel, the Science Committee chair, also resigned. Huntress and Kennel are both former NASA associate administrators, and Huntress is president of The Planetary Society. The forced resignations followed disagreement about what sort of advice the NAC requires. The administrator wants science advice confined to NASA's existing program.

Huntress said, "I was honored to have been asked to assist in the inauguration of the new NASA Advisory Council and my role in that process is complete. The NAC is dedicated to supporting the administrator's decisions on how NASA will meet the administration's goals for the Vision for Space Exploration, particularly returning humans to the Moon. I wish the agency every success in that effort and sincerely hope that science will be a partner in that enterprise."

Huntress' statement emphasizes that NASA's advisers are expected to focus their attention on existing policies and programs, primarily about the lunar component of the Vision for Space Exploration. Administrator Griffin has commented on the current situation, saying, "The scientific community expects to have far too large a role in prescribing what work NASA should do."

The forced resignations and Griffin's comments have increased the schism between the U.S. space agency and the scientific community that developed last spring in response to the huge cuts made in NASA's science program budgets.

Washington, D.C.—With no public announcement, the U.S. administration dropped the phrase "to understand and protect the Earth" from NASA's mission statement. To place our home world in perspective as a member of a family of planets has been a great contribution of NASA's scientific endeavors for the last 30 years. And now, in silence, all that has changed.

This is one more blow against science as the guiding principle for space exploration and one more reason to continue our vigorous campaign to Save Our Science. We face a long campaign with many battles, because the U.S. administration (hence, NASA) has been unwavering in its determination to cut science funding and cancel new missions of planetary exploration. It has rejected funding to maintain the current program as it begins to implement the Vision for Space Exploration.

We won an early battle in our campaign when the U.S. House of Representatives approved a NASA appropriations bill that restored some science funding and provided a "new start" for a Europa mission. But the Senate Appropriations Committee took a different tack, seeking to add money to the NASA budget without specifying where it would go. More money would be good, but the administration, and probably the House of Representatives, opposes the extra funding. Differences between the House and Senate versions will have to be resolved by a conference committee, although many observers predict that as Congress and the administration rush into election-year politicking, neither version will be considered.

This September, even while the 2007 budget is unsettled, the 2008 budget battle began. NASA and the administration will begin working on their next plan, which goes to Congress next February. The Planetary Society will be working to change administration attitudes about science—on Earth, in space, and on other worlds. Watch your mailbox for updates and check our website at *planetary.org/sos*.

Beijing, China—Space scientists from around the world gathered here in July for the biannual meeting of COSPAR (Committee on Space Research of the International Council of Scientific Unions). At COSPAR, and the following week at a meeting of the International Lunar Exploration Working Group (ILEWG), The Planetary Society presented a proposal for an International Lunar Decade, modeled on the tremendously successful International Geophysical Year of 1957–1958.

ILEWG endorsed the International Lunar Decade and other programs to foster cooperation among the many nations now planning missions to explore the Moon. We proposed that the Decade begin next year, when China and Japan both plan to launch lunar orbiters.

China announced its intent to launch in April, and Japan in July. India will follow with a lunar orbiter now earmarked for early 2008. The United States hopes to launch its return to the Moon with an October 2008 lunar orbiter, and Italy announced that it is studying a lunar orbiter mission for a 2010 launch.

In Beijing, Russian space leaders presented what might be the most ambitious lunar mission plan yet: the mission called *Globe* would send a lunar orbiter, plus 16 penetrators, to form a seismic network around the Moon. The Russians also hinted of new support from their government for human spaceflight, perhaps sending humans to the Moon within the next decade. Russian presentations tend to be grander than their financial support would warrant, but current talk about the *Globe* mission is widespread.

The Moon is a stepping-stone for ambitions in space: for exploration, for human spaceflight, for national technological development, and, we hope, for international cooperation for even grander spacefaring ventures to Mars and beyond.

Society News

Introducing . . . . a New Face for Volunteers

We are delighted to announce that Rita Szeto, who recently celebrated her first year on staff as The Planetary Society's sales coordinator, will now oversee the Society's International Network of Volunteers.

Rita will join forces with Global Volunteer Leader Lonny Baker to work with volunteers to extend the reach and resources of the Society. Volunteers are a vital part of who we are and what we do. They coordinate and represent the Society at public events and celebrations, they assist staff with projects, they promote membership, and they engage the public in Society projects.

Lonny, who has volunteered with the Society for more than 20 years, suggests that if you are a volunteer, introduce yourself to Rita and share with her your experiences and advice: call her at (626) 793-5100 or e-mail her at *rita.szeto@planetary.org*. Lonny would love to hear from you as well, at *tps.lb@planetarysociety.org*.
—Andrea Carroll,
Director of Development

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Planetary Society Vice President Bill Nye the Science Guy accompanied me to China and spoke at the Beijing Planetarium to a group of young people about the passion, beauty, and joy of space science. The planetarium is a magnificent facility, reminiscent in design and impact of the Rose Center Hayden Planetarium in New York. The Planetary Society and Beijing Planetarium have agreed to cooperate on public information and education programs, and Society members will receive a discount for admission there, as well as at many other planetariums worldwide. Visit *planetary.org/join/planetariums.html* for a list of participating institutions.

Moscow, Russia—Roscosmos, the Russian Space Agency, has approved funding for a Phobos sample return mission, called *Phobos Grunt* (soil). The mission's goal is to launch in October 2009, the same year as the U.S. *Mars Science Laboratory* and two years before the European *ExoMars*. Phobos has long fascinated Russian scientists, and in 1988 they sent a mission there that succeeded in getting close and observing the satellite of Mars but did not reach its final goal of rendezvous and sending small landers to its surface. Returning a sample of Phobos to Earth would be a major achievement and perhaps a precursor to the long-sought international sample return mission to Mars.

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

Questions and Answers

Astronaut Brian Duffy sampled a beverage during a crew food evaluation session at the Johnson Space Center's food laboratory. Photo: NASA

Astronaut Edward M. Fincke juggles fruit in the weightless environment of the International Space Station. Scientists pay close attention to the nutritional needs of human space explorers, and studies of how to keep astronauts in optimum health are constantly under way. Photo: NASA

How do scientists calculate food requirements for astronauts? Would human explorers on a long-duration voyage have nutritional needs far greater than those on shorter missions? Does working in a weightless environment reduce the human body's need for calories?
—Rene R. Shaw
Potomac, Maryland

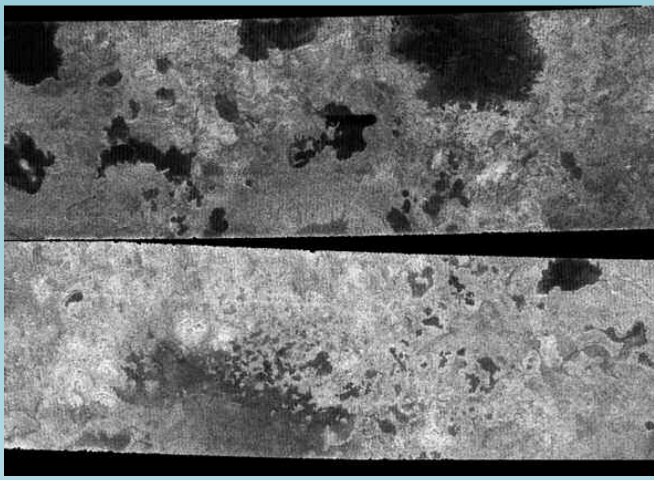
Defining the nutritional requirements for space travelers is indeed a challenge, and studies of nutritional requirements in astronauts are under way. History has proven time and again how nutrition and food can have a profound impact on the success of exploration missions. Early sailors discovered the importance of vitamin C in the human diet—many of them doing so at their peril. It is critical for crew health that all nutrients are provided in their diets in adequate, but not excessive, amounts. Unlike those early sailors, astronauts will not be able to find food as they explore space.

Energy (calorie) requirements for astronauts are determined using equations similar to those used for people on Earth. These equations account for individual differences in size, gender, and age. In the early 1990s, research showed that astronauts used as many calories during flight as they did on the ground. In some cases, when the crews exercised more than usual during flight, they expended more energy in space than they did on the ground. Thus, a person's need for calories during spaceflight is not reduced.

Other nutrients are also of concern for astronauts. Vitamin D stores in the human body are reduced during and after spaceflight—partly related to the fact that spacecraft are shielded from ultraviolet light. Iron and red blood cells are affected by spaceflight. It seems that fewer red blood cells are needed to transport oxygen to the extremities. The reduction in red blood cells, and perhaps other factors, results in increased iron stores—and we work to minimize dietary iron intake as a result. Minerals such as potassium, magnesium, phosphorus, and others are affected by muscle and fluid changes that occur in weightlessness. Ongoing research will help us to understand how the body's need for nutrients changes during flight and how nutrition can help to ensure crews' health before, during, and after their trips to space.

Researchers are also working on finding ways to counteract some of the negative effects of spaceflight on the human body, such as bone loss, muscle loss, cardiovascular changes, and the effects and risks associated with radiation exposure.
—SCOTT M. SMITH,
Johnson Space Center

Factinos



Cassini's radar system has detected strong evidence of lakes of liquid hydrocarbons on Titan. In these images, taken on July 21, 2006, well-defined dark patches that resemble Earthly lakes appear to be sprinkled all over the high latitudes surrounding the Saturnian moon's north pole.

Scientists have long speculated that liquid methane or ethane might form lakes on Titan. Some of the dark patches have channels leading into or out of them, and these channels have shapes that strongly imply they were carved by liquid. The top image is centered near 80 degrees north, 92 degrees west and measures about 420 by 150 kilometers (260 by 90 miles). The lower image is centered near 78 degrees north, 18 degrees west and is about 475 by 150 kilometers (295 by 90 miles). Images: NASA/JPL

Cassini has found lakes on Titan. The lakes are most likely the source of the complex soup of hydrocarbons in the frigid Saturnian moon's atmosphere, and finding the origin of this "smog" has been a major goal for the *Cassini* team (see image above).

Several dozen well-defined dark patches resembling lakes are present in radar images of Titan's high latitudes taken during *Cassini*'s July 22, 2006 flyby. At Titan's frigid temperatures, about –180 degrees Celsius (about –290 degrees Fahrenheit), the liquids in the lakes are most likely methane or a combination of methane and ethane.

Cassini had not flown over this area on Titan before because it has been in shadow since before the spacecraft arrived. During the flyby, *Cassini*'s radar spotted lakes as small as 1 kilometer (0.6 mile) wide, with some about 32 kilometers (20 miles) wide. The biggest lake is nearly 100 kilometers (62 miles) long and may be only partly wet.

"This is a big deal," said Steve Wall of the Jet Propulsion Laboratory. "We've now seen a place other than Earth where lakes are present."

"What we see is darker than anything we've ever seen elsewhere on Titan," said Larry Soderblom of the United States Geological Survey in Flagstaff. "It was almost as though someone laid a bull's-eye around the whole north pole of Titan, and *Cassini* sees these regions of lakes just like those we see on Earth. Titan has turned out to be like a musical crescendo—each pass is more exciting than the last."

—from NASA/JPL

For more information, go to *http://planetary.org/news/2006/0724_Cassini_RADAR_Reveals_Lakes_on_Titan_At.html.*

When 2,500 astronomers from 75 countries at the International Astronomical Union's (IAU) annual meeting in Prague voted on a resolution that aims to define exactly what a planet is, Pluto got the boot.

This result of a vote on August 24, 2006 means that Pluto has been ejected from the planetary brotherhood. It is no longer considered a planet, but rather, a "dwarf planet." As a result, the solar system now consists of eight recognized "planets": Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

A planet is now defined as a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighborhood around its orbit.

This marks the first time the IAU has put forth scientific criteria for defining a planet and voted on the issue. A new class of objects called dwarf planets was also defined, as the astronomers agreed that planets and dwarf planets are two distinct classes of objects.

A dwarf planet, according to the new definition, is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, (c) has not cleared the neighborhood around its orbit, and (d) is not a satellite.

All other objects orbiting the Sun will now be referred to collectively as "small solar system bodies."

The first members of the dwarf planet category are Ceres, Pluto, and Eris (the newly announced name of 2003 UB313, which was also informally known as Xena). More dwarf planets are expected to be announced by the IAU in the coming months and years. Currently, about a dozen candidate dwarf planets are listed on the IAU's list of dwarf planets to watch, which keeps changing as new objects are found and the physics of the existing candidates become better known.

For Pluto supporters, not all is lost. Pluto is being recognized, according to the IAU, as "an important prototype of a new class of trans-Neptunian objects." The IAU will set up a process to name these objects.

A specially selected committee spent two years, under the auspices of the IAU, working on the proposal to define what, exactly, should be deemed a planet, as well as a way to better describe the difference between planets and smaller solar system bodies, such as comets and asteroids.

—from *planetary.org*

To read the rest of this story, go to *http://planetary.org/news/2006/0824_Pluto_Gets_the_Boot__Solar_System.html.*

For a history of the shake-up in our solar system, go to *http://www.planetary.org/explore/topics/pluto/new_solar system.html.*

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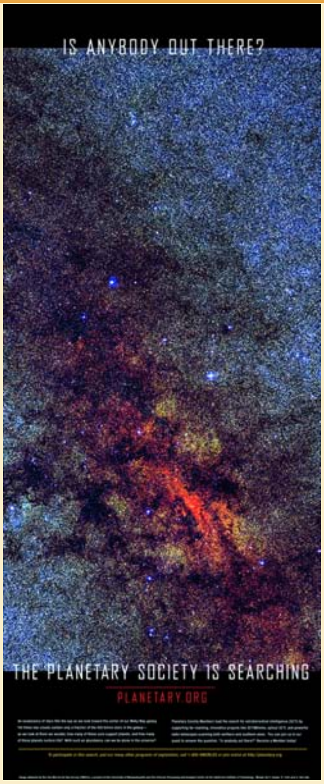

"Is Anybody Out There?" Poster
This astounding image, obtained by the Two Micron All Sky Survey, reveals only a fraction of the 400 billion stars in our own Milky Way galaxy. 39" x 16"
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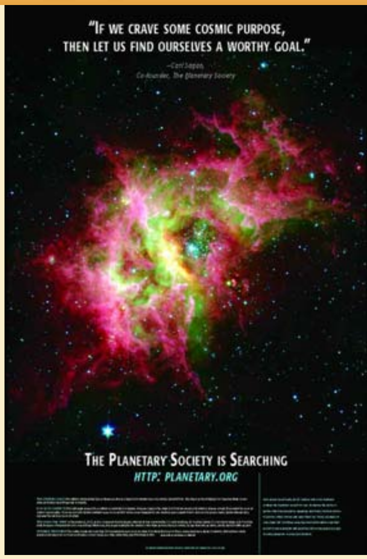
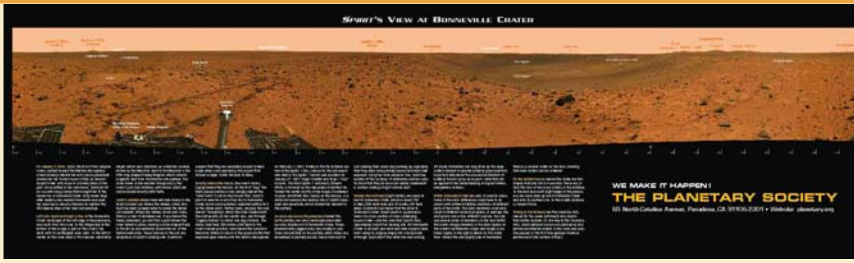


Nebula Poster
This awe-inspiring image from NASA's orbital Spitzer Space Telescope shows a false-color infrared view of nebula RCW 49—a birthplace for many hundreds of new stars and likely many thousands of planets.This stunning poster features one of Carl Sagan's poignant statements: "If we crave some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



***Spirit*'s View at Bonneville Crater Poster** On January 3, 2004, *Spirit*, the first of two complex rovers, hurtled toward the Martian atmosphere and bounced down onto the dusty surface. Sixty-seven days after landing, it reached the raised rim of Bonneville Crater and used its panoramic camera to capture this 360-degree view of its new surroundings. 10" x 39" 1 lb. **#350 $13.50**

Mars in 3-D Poster Put on your red/blue glasses and step onto the Martian surface, where *Mars Pathfinder* still rests today. Red/blue glasses included. 12" x 39" 1 lb. **#306 $13.50**

Pale Blue Dot Poster
In February 1990, *Voyager 1* looked back at its home planet for the first time. The image of Earth as a tiny bluish dot inspired Carl Sagan to write one of his best-known essays, which starts off his book *Pale Blue Dot*. The poster features Carl's timeless words and the full frame of the profound image captured by *Voyager 1*. 12" x 30"
1 lb. **#326 $10.00**

Surf Titan T-Shirt
A Planetary Society classic—we first introduced this shirt after *Voyager* passed by Titan, revealing hints of a methane ocean. Now that *Cassini-Huygens* has arrived for a closer look at the mysterious moon, we decided to bring this old favorite out of retirement. This shirt is long-sleeved with "The Planetary Society" printed on the left sleeve. Adult sizes: S, M, L, XL, XXL
1 lb. **#593 $20.00**

Future Martian T-Shirt
The future is full of possibilities, and today's Earth child just might be a future Martian.
Child sizes: S, M, L
1 lb. **#565 $13.50**

"Is Anyone Out There?" T-Shirt
As we gaze out at the heavens toward a vibrant spiral galaxy, the question arises, "Is anyone out there?" This dramatic T-shirt captures the feeling of wonder when pondering our place in the universe. Adult sizes: S, M, L, XL, XXL
1 lb. **#586 $19.95**

SETI@home Mug
More than 5 million participants have contributed their time and computers to SETI@home, the largest distributed computing experiment ever undertaken. Our new 11-ounce mug features a wraparound image of the SETI@home screen saver.
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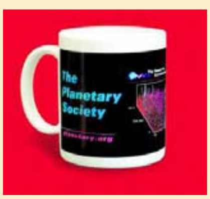

"Top Three Reasons I Want to Move to Mars" Mug
Would you want to live on Mars? This humorous mug featuring an image of *Spirit*'s landing site suggests three added benefits of life on the Red Planet. 2 lb. **#610 $16.00**

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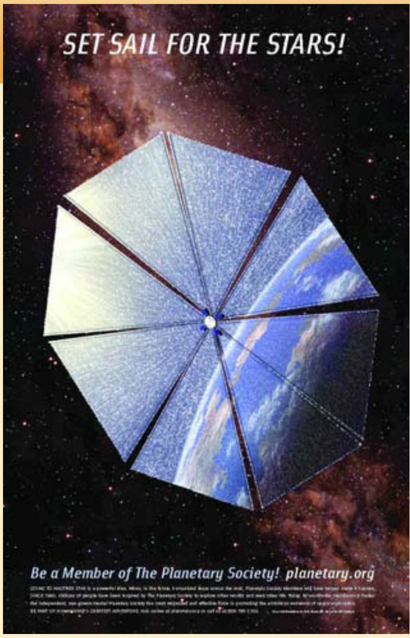

Set Sail for the Stars! Poster
A solar sail takes off in flight, leaving its home planet behind. In the distance, the Milky Way beckons. This stunning illustration created by Rick Sternbach captures both the elegance and the promise of solar sailing, the only known technology that may one day take us to the stars.
22" x 34" 1 lb.
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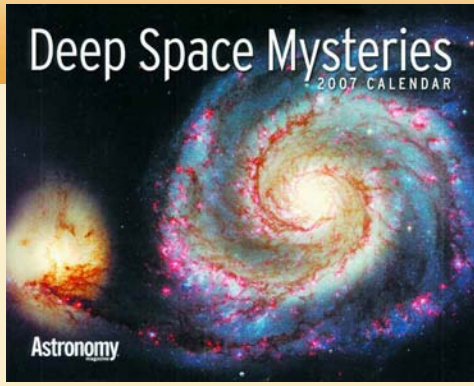

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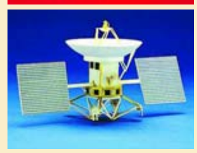

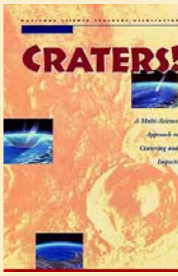

***Craters!* A Multi-Science Approach to Cratering and Impacts**
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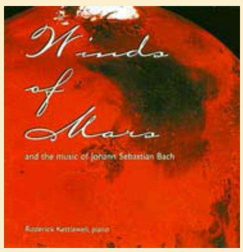

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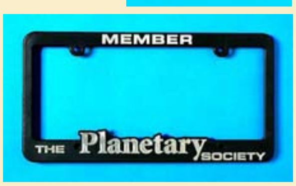

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Little Pluto, long a favorite with the general public, especially children, has been the eye in the tornado of hot debate over what, exactly, qualifies as a planet. The International Astronomical Union has reclassified Pluto as a "dwarf planet," but it remains one of the most mysterious worlds in our solar system, regardless of its standing in the fraternity of bodies orbiting our Sun. In *Surface of Pluto*, the large moon Charon looms over the horizon and a very thin atmosphere with high cirrus clouds—caused by erupting geysers on the surface—can be seen, while our Sun and the Milky Way sparkle in the dark, clear sky.

Edwin Fauhn's space art has appeared in many publications, including *Scientific American, Astronomy,* and *Sky & Telescope*. He lives and works in Memphis, Tennessee.

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