The PLANETARY REPORT

Volume XXVIII Number 2 March/April 2008

Visions of Exploration

From The Editor

We like to look back at the time of *Apollo* and remember how, for a brief moment, the people of Earth pulled together to place a man on the Moon.

Memories can be faulty. Opinion polls taken at that time repeatedly showed that the public was never solidly behind the space program. Among political leaders, scientists, and engineers, there was never consensus on the right path to take. Books were written chronicling the decisions, from John F. Kennedy's political resolve to land a man on the Moon to the engineering choice to use lunar orbit rendezvous.

Nearly a half-century later, we are wrestling again with how to move humanity into space. Four years ago, U.S. President George W. Bush laid out his Vision for Space Exploration and tasked NASA with finding the best path back to the Moon and onward to Mars. This new vision would be bigger than *Apollo*, be far more expensive, and last many more years.

Figuring out how to do that—and get the fractious community of scientists, engineers, and policy makers to agree—has been, as they say, like herding cats. The Planetary Society, with Stanford University, brought together representatives of the space community in a workshop called "Re-examining the Vision." This spring, through a series of town hall meetings, we are inviting the public to contribute their views.

To explore space is difficult. We must choose to do what is hard. Join us as we seek a way back to the Moon—and on to Mars.

—Charlene M. Anderson

On the Cover:

This mosaic view of Mars' north polar region is composed of wide-angle camera daily global mapping images taken by *Mars Global Surveyor* in October 2006. The polar cap is visible at center right, and two annular (somewhat circular) clouds are visible at upper left. Annular clouds are common in midnorthern summer in Mars' north polar region, and they may be from eddy currents in the lower atmosphere.

Although most of Mars is dry, its polar regions are rich in water ice. *Phoenix* is on its way to study the structure, composition, and chemistry of soil and ice samples near the Red Planet's north pole.

Image: NASA/JPL/Malin Space Science Systems

Background:

Opportunity's Panoramic Camera took this image of the dunes inside Beagle crater on August 10, 2006 (Martian day, or sol, 905). Beagle, which is 35 meters in diameter, sits on the edge of the ejecta blanket surrounding the much larger Victoria crater (750 meters), located in Mars' Meridiani Planum. Image: NASA/JPL/Cornell University

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The Planetary Report (ISSN 0736-3680) is published bimonthly at the editorial offices of The Planetary Society, 65 North Catalina Avenue, Pasadena CA 91106-2301, 626-793-5100. It is available to members of The Planetary Society. Annual dues in the United States are $30 (U.S. dollars); in Canada, $40 (Canadian dollars). Dues in other countries are $45 (U.S. dollars). Printed in USA. Third-class postage at Pasadena, California, and at an additional mailing office. Canada Post Agreement Number 87424.

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A PUBLICATION OF THE PLANETARY SOCIETY

OPINION

On the Road to Mars: Three Stepping-Stones and a Stumbling Block

Mars and Phobos *by Walter Myers*

Although those interested in off-Earth human exploration generally agree that Mars is a key destination, opinions differ regarding the steps for getting humans to the Red Planet. Some advocate going directly to Mars without any intermediate destinations, whereas others believe we need to practice at the Moon before taking on the big step of sending humans to our nearest planetary neighbor. The interim technical steps continue to be debated, and this article presents one aspect of the debate. —Editor

by Robert Farquhar

In its Vision for Space Exploration (VSE), NASA has focused on a Moon base as the next logical step on the road to Mars. As specific plans become more defined, however, it is becoming painfully obvious that the Moon is not a stepping-stone to Mars but is instead a stumbling block. The enormous cost of Moon base infrastructure will drastically reduce the funding available for science programs and related exploration. If NASA's lunar base strategy is allowed to proceed, human missions to Mars will be delayed by at least 50 years.

Proponents of the concept of a Moon base advertise three main benefits. They cite the utility of a Moon base as a hub for expanded human exploration of the lunar surface. They also say the Moon could serve as a platform for large telescopes. Finally, the lunar aficionados claim the Moon would be an ideal place to test the technologies and techniques that will be needed for human missions to Mars. All three of these justifications are questionable at best.

Exploration of the Moon's surface, if it is a goal worth pursuing, can be accomplished more efficiently by robotic spacecraft, and at a much lower cost. Placing large telescopes on the dusty Moon makes no sense either (with the possible exception of a radio telescope on the Moon's far side); space-based telescopes offer a far better option in terms of performance, accessibility, and cost—with no lunar dust. Finally, the notion that the Moon could serve as a proving ground for Mars missions strains credulity. Try to imagine the Lunar Surface Access Module (LSAM), a vehicle designed for an airless environment, ever landing on Mars.

For these reasons and many others, the VSE needs a major course correction. The time has come for the space interest community to speak up and tell NASA management that its Moon base proposal "has no clothes." Fortunately, there is an alternative focus for VSE that avoids the lunar cul-de-sac.

The IAA's Next Steps Study

An alternative plan, based on a study done under the auspices of the International Academy of Astronautics (IAA), improves on the NASA Moon plan in several ways. The most important is that it offers a credible path toward the goal of human presence on Mars. The IAA plan also gets more science done along the way, it provides vehicles and know-how that will be needed for Mars missions, and, crucially, it avoids burying the whole enterprise of exploration in Moon-specific costs.

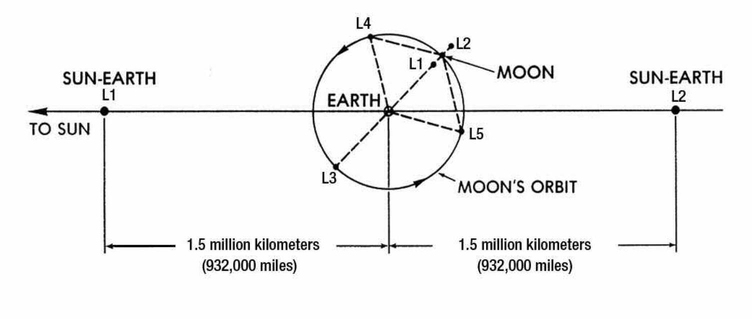
A significant cost-managing feature of the IAA plan is its emphasis on reusable hardware. One of the reusable elements is a crew transfer vehicle stationed in low Earth orbit (LEO). Vehicles of this type would be used repeatedly for round trips to destinations at intermediate distances—for example, servicing space-based telescopes at Sun-Earth libration points. This LEO-based vehicle, or Deep Space Shuttle, would provide the basis for the development of a similar, but much larger, crew transfer vehicle for longer hauls. The long-haul version, also reusable, would be parked at Sun-Earth L2 for trips to interplanetary destinations.

The IAA study proposes a three-step approach:

1. establishment of a staging node near Sun-Earth L2 for human missions beyond the Earth-Moon system,
2. a human mission to a near-Earth asteroid, and
3. a human mission to one of the Martian moons.

Instead of sinking resources into a Moon base, the IAA strategy is organized around a more cost-effective series of milestones in space, each of which will literally bring us closer to Mars.

Libration Points in the Vicinity of the Earth



As shown by the eminent French mathematician Joseph Lagrange in 1772, there are five positions of equilibrium in a rotating two-body gravity field. A spacecraft placed at one of these points with the proper velocity would be in equilibrium because its centrifugal acceleration would be balanced by the combined gravitational attractions of the two bodies. There are seven of these "libration points" near Earth—five belonging to the Earth-Moon system, and two belonging to the Sun-Earth system. *Diagrams: Courtesy of the author*

Smart Use of Libration Points

The L1 and L2 libration points of the Sun-Earth system have become increasingly popular for scientific spacecraft. This is because libration points provide an opportunity for a small body such as a space telescope to maintain a steady position almost for free. Orbits around libration points are inherently unstable, so some stationkeeping maneuvers are required every three months or so, but the associated costs are quite small. The delta-V (amount of effort required to adjust orbital trajectory) is only about three meters per second per year.

On November 20, 1978, the *International Sun-Earth Explorer-3* (*ISEE-3*) became the first libration point spacecraft when it was inserted into a halo orbit around the Sun-Earth L1 point. The highly successful flight of *ISEE-3* demonstrated the utility of libration point orbits. Between 1995 and 2001, five more spacecraft took advantage of these locations.

Others will soon follow. Beginning this year, halo orbits around the Sun-Earth L2 point will be the locations of choice for a number of large astronomical facilities, including the James Webb Space Telescope (JWST). The L2 site offers a number of key advantages, including a spectacular view. With the Sun, Earth, and Moon behind it, a space telescope at L2 can observe more than half of all space at all times. The short distance to Earth enables easy communications, and thermal control is simpler than it would be with lunar day/night cycles.

Servicing Sun-Earth L2 Telescopes

One of the most significant achievements of the space shuttle program was servicing the Hubble Space Tele-

The establishment of a staging node at the Sun-Earth L2 point would prepare human explorers to venture beyond the Earth-Moon system to these nearby worlds. Above, astronauts tend to a mining operation on Mars' moon Phobos. *Illustration: Pat Rawlings*

A colony with an observatory has been built inside a crater on an Eros-like near-Earth asteroid. *Illustration: Hannu Parviainen*

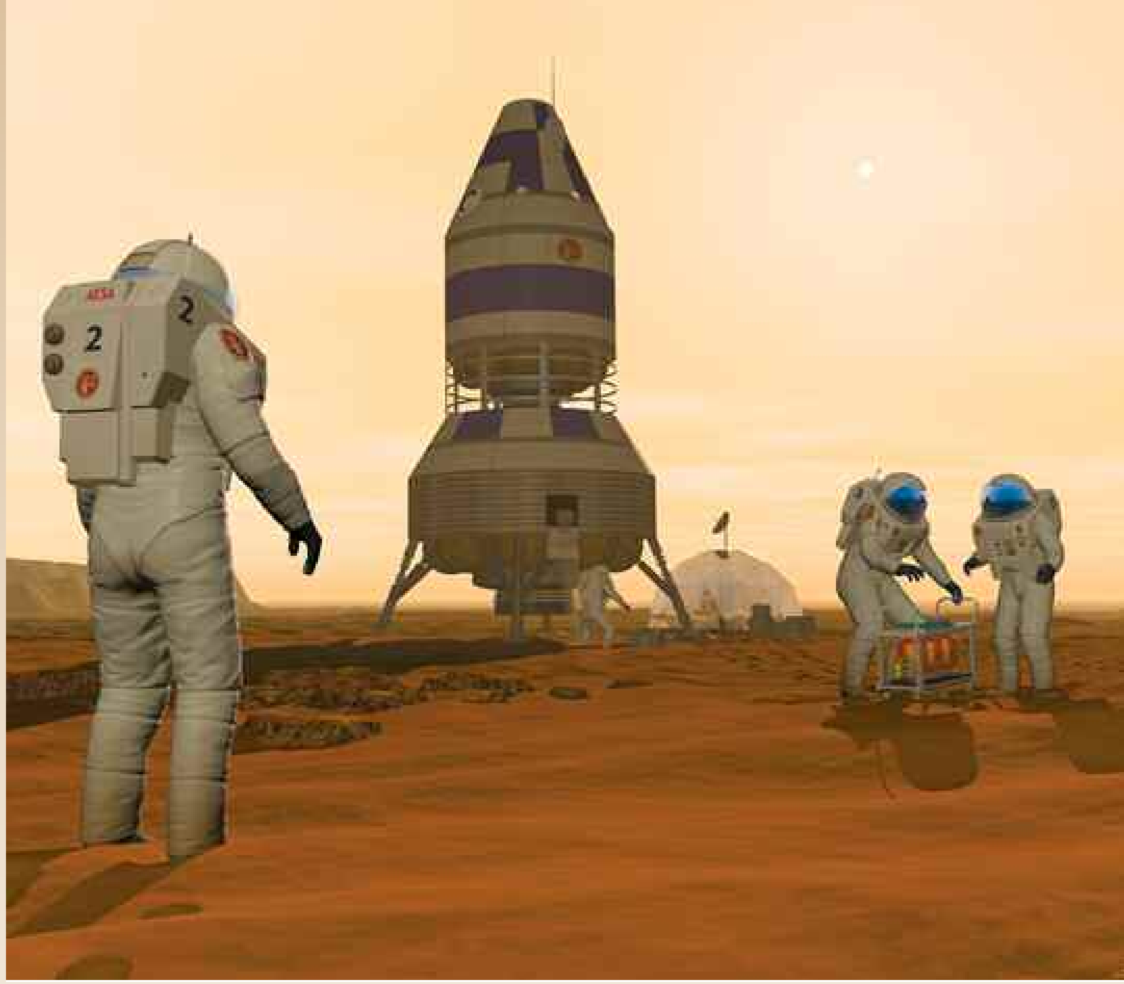
scope. The JWST mission is not designed for human servicing, but the need for maintenance and repair capabilities is inevitable as L2 telescopes become larger, more complex, and more expensive. With that in mind, the IAA study team looked at servicing L2 telescopes as an initial step toward expanding human space activities beyond LEO. One way to acquire this capability would be to develop a reusable vehicle called the Deep Space Shuttle (DSS). The primary components of the DSS would be

- a service module with quarters to support a crew of three or four people for flight times of up to 50 days;
- a detachable, *Apollo*-style reentry capsule (the Crew Exploration Vehicle [CEV] under development by NASA would be a logical candidate for this component); and
- a chemical propulsion system using storable propellants such as liquid oxygen/methane.

As for its technical characteristics, the DSS is envisioned as a one-and-a-half-stage vehicle (that is, a core stage with drop tanks). The total delta-V capability of the DSS would be somewhere between 5 and 6 kilometers per second. The delta-V requirement could be reduced, however, by roughly 3.2 kilometers per second if an expendable Earth departure stage is employed.

The baseline mission profile for a DSS trip from LEO to L2 and back is summarized in the diagram on page 8. It is interesting to note that the delta-V requirement for the transfer to L2 is virtually identical to the delta-V cost for a transfer between LEO and a low lunar orbit. The cost is the same, even though the transfer time for L2 is almost four times as long.

An interesting alternative strategy for servicing L2 telescopes would, so to speak, bring the mountain to Muhammad. That is, the L2 telescope would travel to an elliptical Earth orbit using a lunar gravity–assist maneuver. A DSS crew would service the telescope in the elliptical Earth orbit, and then the telescope would return to L2 with a second lunar gravity assist. The delta-V cost for this lunar double-swingby scenario is very small (less than 25 meters per second). With this technique, the round-trip flight for the DSS would be reduced to 14 days,



The first human visitors to Mars face an environment nearly as hostile as that of Earth's Moon. Illustration: Walter Myers

and the delta-V savings would be at least 1 kilometer per second.

The development of a DSS will be a critical element in the architecture, enabling human crews to reach more distant destinations.

Sun-Earth L2 Staging Node

Although the DSS would have the ability to transport astronauts to destinations well beyond the Moon's orbit, a larger and more capable transfer vehicle will be needed for flights to near-Earth asteroids, to Phobos or Deimos, and to Mars. To satisfy this requirement, the IAA study calls for a reusable vehicle based in a halo orbit around the Sun-Earth L2 point. This Interplanetary Transfer Vehicle (ITV) would carry astronauts to and from interplanetary destinations.

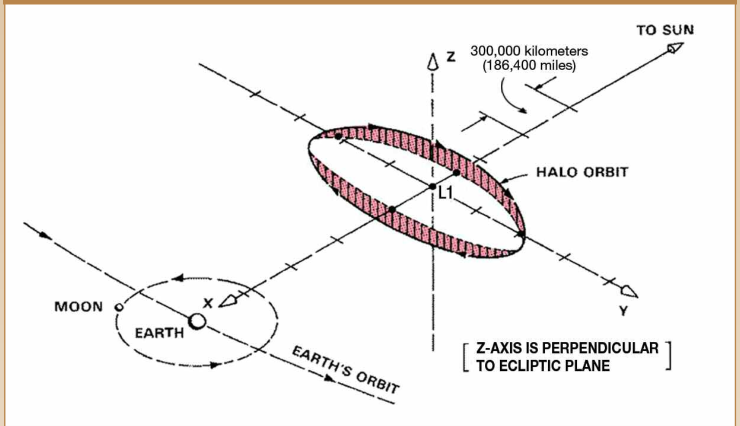
The proposed components of the ITV are as follow:

- A crew module that could support five or six people for flight times up to three years. This module would be constructed at L2 over a period of several years. Early versions would be used for excursions to near-Earth asteroids.
- A propulsion module, which could be reusable or expendable depending on the flight rate and advances in rocket engine technology. Use of a nuclear thermal rocket could also be considered to achieve shorter transit times.
- A detachable and reusable *Apollo*-style reentry capsule.

The general mission scenario for trips to interplanetary destinations using the L2 staging concept is outlined in the diagram on page 9. The empty ITV, parked in a halo orbit at Sun-Earth L2, is summoned to an ellliptical Earth orbit to rendezvous with the crew. Small propulsive maneuvers (total delta-V less than 50 meters per second) and lunar gravity assists are used to target the final perigee delta-V maneuver. A DSS "taxi" transfers the crew from LEO to the ITV in its elliptical Earth orbit.

With the crew aboard and all systems checked out, the ITV executes an Earth-escape maneuver and proceeds to its interplanetary destination. After completing the mission, the ITV brings the crew back to Earth's vicinity, and the crew uses the reentry capsule to return to Earth. The ITV, without crew, then uses a perigee maneuver for Earth

Halo Orbit Around the Sun-Earth Libration Point



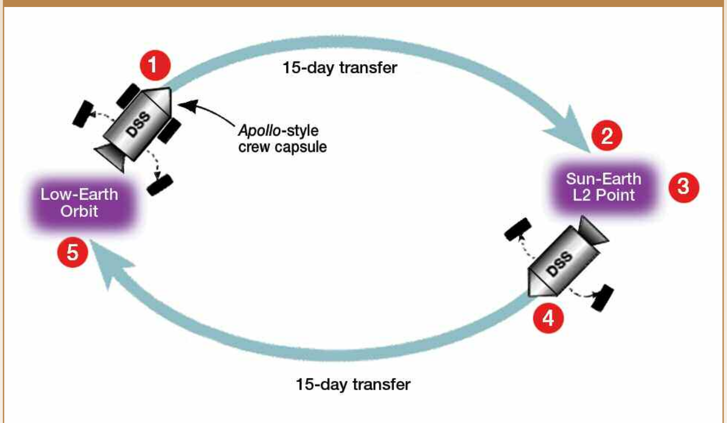
A halo orbit is unusual in that it has no planet or other massive body at its center. The halo orbit around the Sun-Earth L1 libration point is illustrated here. This was the mission orbit for NASA's* ISEE-3*, and ESA's* SOHO *spacecraft.

Libration-Point Missions 1978–2015

Mission	Sun-Earth Libration Point	Date of Orbit Insertion	Mission Purpose
ISEE-3 (NASA)	L1, L2	1978, 1983	Solar wind, cosmic rays, plasma studies
WIND (NASA)	L1	1995, 1997	Solar wind monitor
SOHO (ESA/NASA)	L1	1996	Solar observatory
ACE (NASA)	L1	1997	Solar wind, energetic particles
MAP (NASA)	L2	2001	Cosmic microwave background
Genesis (NASA)	L1	2001	Solar wind composition
Herschel (ESA)	L2	2008	Far-infrared telescope
Planck (ESA)	L2	2008	Cosmic microwave background
GAIA (ESA)	L2	2012	Galactic structure, astrometry
JWST (NASA)	L2	2013	Deep space observatory
XEUS (ESA)	L2	2015	X-ray spectroscopy
Darwin (ESA)	L2	2015	Infrared space interferometry

Abbreviations:
ISEE (International Sun-Earth Explorer)
SOHO (Solar Heliosphere Observatory)
ACE (Advanced Composition Explorer)
MAP (Microwave Anisotropy Probe)
GAIA (Global Astrometric Interferometer for Astrophysics)
JWST (James Webb Space Telescope)
XEUS (X-ray Evolving Universe Spectrometer)

Mission Scenario for Telescope Servicing at Sun-Earth L2 Libration Point



Left: This is a typical mission scenario for servicing telescopes located in the vicinity of the Sun-Earth L2 libration point. Step 1: The Deep Space Shuttle (DSS) leaves low Earth orbit (LEO) at delta-V of about 3,230 meters per second. Here, the first set of drop tanks is discarded. Step 2: The DSS enters L2 orbit at delta-V of about 900 meters per second. Step 3: The crew services the L2 telescope. Step 4: The DSS leaves L2 orbit at delta-V of about 900 meters per second. Step 5: Astronauts return to Earth in an* Apollo*-style capsule, and the DSS returns to LEO using multiple aero-braking maneuvers.

capture, followed by lunar gravity assists and small propulsive maneuvers, to return to its L2 base.

Mission to a Near-Earth Asteroid

It's reasonable to ask why we should keep the ITV parked at Sun-Earth L2 rather than in a low Earth orbit. To understand the performance advantage of basing a reusable ITV at Sun-Earth L2, it is instructive to compare the delta-V costs of the two staging locations for an example mission to a near-Earth asteroid. A particularly good opportunity for an early piloted mission to a near-Earth asteroid is illustrated in the figure at the top left of page 9.

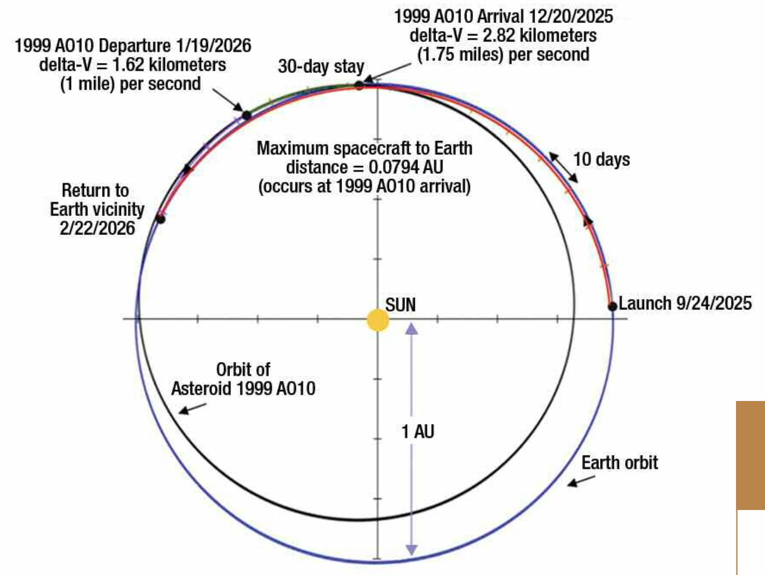
An ITV operating from L2 can perform this mission for a delta-V cost of only 4.9 kilometers per second, which is less than half the cost for an ITV based in LEO. Savings of this magnitude would be enough to preclude the need for a heavy-lift launch vehicle such as the Ares 5. (Acquisition of an Ares 5 launcher may be desirable for other reasons, including delivery of very large payloads to L2, such as telescopes with apertures of 30 meters or more, components for ITV construction, and propellant for ITV flights.)

The 2025 opportunity for a mission to asteroid 1999 AO10 is appealing for a number of reasons:

- It would be a perfect rehearsal for a human mission to Phobos or Deimos.
- The round-trip flight time is only five months, with a 30-day stay at the asteroid.
- The ITV would always remain within 0.08 AU of the Earth (AU = astronomical unit, the average distance between Earth and the Sun, about 93 million miles or 150 million kilometers).

The mission would have the robust capability to turn around and come back if necessary. Even a week after the Earth-escape maneuver, the ITV would have enough remaining delta-V capability to return home in less than

Five-Month Mission to Near-Earth Asteroid 1999 AO10

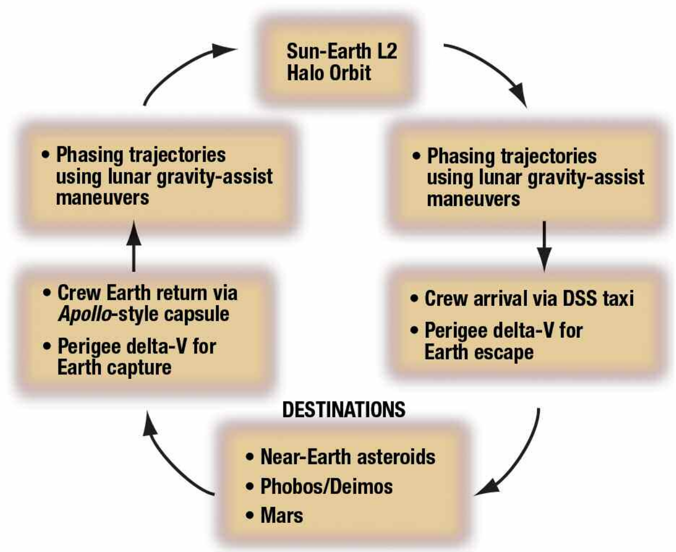


Interplanetary Transfer Vehicle	
Staging Location	Round-trip delta-V (km/sec)
Low Earth Orbit	11.2
Sun-Earth L2 point	4.9

Above: This is the trajectory profile for a five-month interplanetary round-trip mission to the near-Earth asteroid 1999 AO10. A reusable ITV parked in orbit at Sun-Earth L2 is more than twice as efficient as one based in LEO in terms of delta-V cost (energy expenditure) because the L2 point is located at the edge of Earth's gravity well.

Below: The basic steps for a reusable Interplanetary Transfer Vehicle (ITV) to carry human explorers to and from destinations beyond the Sun-Earth-Moon system (near-Earth asteroids, Phobos and/or Deimos, and Mars) are mapped out here.

Interplanetary Transfer Vehicle Mission Scenario



four days. If successful, the mission to this near-Earth asteroid would take its crew farther into deep space than humans have ever traveled.

A Future for Human Spaceflight

No such flight can take place if the Moon base now on the drawing board sucks every budget dollar from NASA's scientific programs. The Moon base, though promoted as a return to space, therefore in fact represents a dead end. In contrast, the IAA strategy points the way toward practical exploration, with a realistic possibility of human expeditions to Mars before 2050.

Looking at the long term, it is vital to the future of human spaceflight that NASA plans and missions generate public enthusiasm. We have to inspire people by planning and doing things that have never been done before. The IAA plan identifies a series of new accomplishments, each extending our reach into the solar system.

The Deep Space Shuttle will take human missions beyond the Moon's orbit for the first time. Emplacement of large astronomical observatories near the Sun-Earth L2 libration point will be a proud achievement, flowing from rather than competing with high-priority science, and it will capture imaginations throughout the world, as Hubble did. Development of a substantial and capable ITV, with shielding and living quarters for astronauts to travel to Mars in safety and comfort, will give the public its first true interplanetary spaceship.

If plans for a Moon base don't stop us in our tracks, the path ahead can lead human explorers to an asteroid, to a Martian moon, and then to Mars.

Space provocateur Robert Farquhar holds the Charles A. Lindbergh Chair in Aerospace History at the Smithsonian Air and Space Museum.

Views expressed in this article are those of the author and do not necessarily represent those of The Planetary Society.

A Message to the Future:

The circular feature in this image, captured by Mars Global Surveyor*'s Mars Orbiter Camera, is a partially buried crater in the Martian arctic. It is surrounded, and partly overlain, by some of the many sand dunes in the area. In summer, the dunes in this scene would appear darker than their surroundings, but in this northern springtime image, the dunes—and everything else in the area—are covered with carbon dioxide frost.* Image: NASA/JPL/MSSS

The **Phoenix** *spacecraft is nearing its May 25, 2008 landing on Mars. On board is a silica glass mini-DVD provided by The Planetary Society that includes a quarter-million names (including those of all Planetary Society members) and a collection of Mars-related literature, art, and audio called* **Visions of Mars.**

Phoenix*'s principal investigator, Peter Smith from the University of Arizona, wrote a special introduction to* **Visions of Mars.** *It is included on the mini-DVD. In it, he sends a message to the future explorers who may one day find the mini-DVD, describes the* **Phoenix** *mission and its goals, and also reflects on our hope of reaching into the future with our message from Earth,* **Visions of Mars.**

Here, we share part of Peter's essay. The complete essay, as well as details about the mini-DVD and **Visions of Mars,** *is at the Society's website at* **planetary.org/phoenixdvd.**
—Bruce Betts, Director of Projects

BY PETER HOLLINGSWORTH SMITH

This message precedes a collection of stories and essays that are intended as a time capsule. Most of these stories come from the most famous science fiction writers of our day. They springboard from the latest scientific knowledge to weave visionary tales of the future. In return, the stories inspire young readers to dream of magical futures and, later as adults, to become part of the leading edge of scientific discovery. This cyclical exchange between fact and fiction is the basis for the creative art of science.

Reading these stories offers us insight into the hopes and fears of society. Edgar Rice Burroughs' stories of conquering monsters and befriending aliens remind us of the still-recent expeditions into the savage and untamed Rockies in the early nineteenth century. More recent novels lead to the terraforming and colonization of Mars, ideas that clearly come from humankind's successful taming of Nature on every continent.

What brave soul might decode this mini-DVD after recovering it from the north polar region on Mars? Possibly a member of a future society that has sent astronauts and pioneers to explore the

"Visions of Mars"

Patterned ground and small boulders as far as the eye can see typify the terrain in the northern polar latitudes. This Mars Reconnaissance Orbiter *HiRISE image shows the texture of the ground in the northern hemisphere plains of Mars, where* Phoenix *is set to land. The bright surfaces in this image are covered with seasonal carbon dioxide frost, which is slowly sublimating away (changing directly from ice to gas) and revealing small hexagonal and polygonal patterns a few meters in size in the darker soil beneath the surface.* Image: NASA/JPL/University of Arizona

solar system will return with this treasure to a curious future civilization. Because the longevity of this disk can be many millennia, there is no way to know just who the readers are or their knowledge about life at the beginning of the space age in the year 2007.

Let me introduce myself to you. I am Peter Smith, the Principal Investigator of the *Phoenix* mission funded by NASA. My father, Hugh Smith, was born in 1902, an era when there was no radio or recorded music or television. His small town had no electricity, and South Carolina had yet to see a car. His career in medical research put him on the forefront of modern medicine; he was a key member of the Rockefeller Foundation team that discovered an affordable vaccine against yellow fever. Born in 1947, I grew up in a home that respected the intellect above all else. I read science fiction voraciously as a child and dreamed of adventures on other planets.

Today, as a planetary scientist at the University of Arizona in Tucson, my dreams have become reality, and the visions of exploration are still very much alive. Our *Phoenix* spacecraft that you have discovered is a robotic emissary, a stepping-stone in our quest for extraterrestrial life. We live within a small time window of the great river of human accomplishment. This time is unique—we have developed our technology, since the beginning of the Industrial Revolution in 1850, to the point that humans have set foot on the Moon and robotic missions explore Mars.

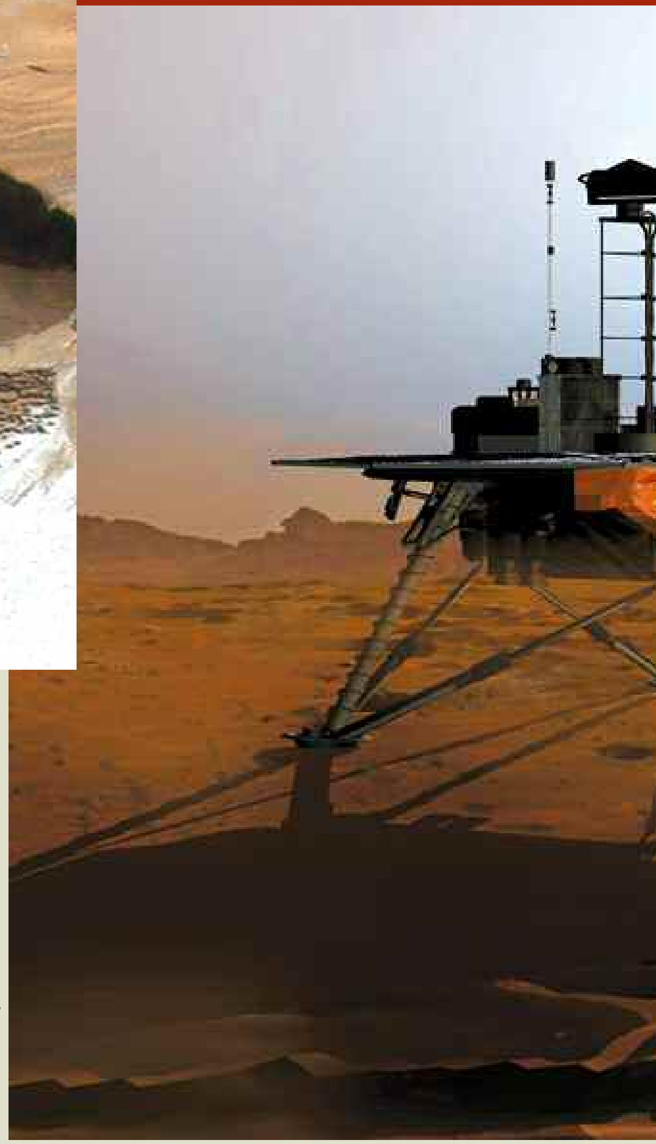
I have seen the technology exhibited in this disk evolve from 78-RPM record disks to 33-RPMs to tape players of various types to CD-ROMs to DVDs. Now we are on the verge of doing away with these media altogether and simply pulling information directly from the Internet onto tiny memory cells. The technology represented by this mini-DVD will not be current even 20 years from now. We nevertheless must try to preserve the part of our culture that reveals the fascination that we have felt over the last 120 years about traveling to Mars and searching for nonterrestrial forms of life.

The *Phoenix* mission is a stepping-stone on a path to search for habitable zones on Mars and then probe for life signatures. Perhaps the future reader of this document already knows that life had a second genesis off Earth. Entire institutes may be devoted to this topic. In 2007, however, we have yet to provide conclusive proof that Mars supports life, either in the past or in the present.

Reasonable scientists can find many reasons to be skeptical on this topic. The thin atmosphere (about 1 percent the density of Earth's) and the greater distance from the Sun provide an environment that is either dry or frozen. Liquid water, necessary for life as we know it, is highly unstable on Mars today. In addition, there is insufficient ozone in the atmosphere to block high-energy ultraviolet radiation. Without protection, organisms cannot survive this radiation for very long. Indeed, the *Viking* spacecraft in 1976 determined in two locations that there were no organic molecules in the surface soils. Worse, they found evidence that oxidants sterilize the surface. Under these conditions, an active Martian biosphere is not favored.

The 2002 discovery did find, however, that a layer of ice underlies the surface poleward of 60 degrees both

Above: This image, taken by the High Resolution Stereo Camera on board ESA's Mars Express*, shows the Martian north polar ice cap with layers of water ice and dust. Here we see cliffs almost two kilometers (more than one mile) high and dark material in the caldera-like structures and dune fields that could be volcanic ash. What will the* Phoenix *lander see from its Martian home?* Image: ESA/DLR/FU Berlin (G. Neukum)

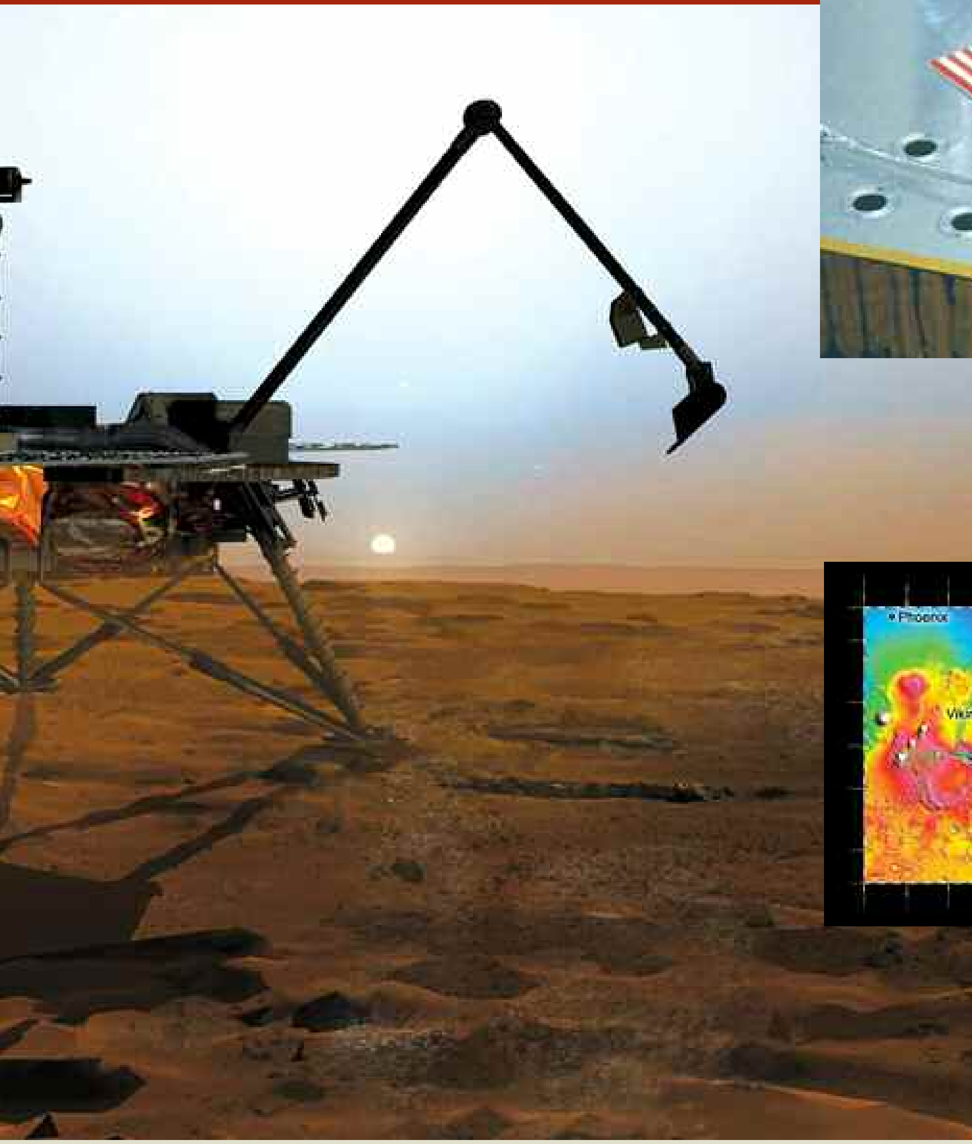


Right: Set to land on Mars on May 25, 2008, Phoenix *will use a robotic arm to dig down to the expected icy layer. It will analyze scooped-up samples of the soil and ice to help scientists evaluate whether the subsurface environment in the Martian arctic ever was, or may still be, a favorable habitat for microbial life. In this artist's conception, the Sun sets on* Phoenix *after a successful mission. With the onset of polar twilight, the spacecraft will no longer be able to charge its batteries and will soon shut down.* Illustration: NASA/JPL, Corby Waste

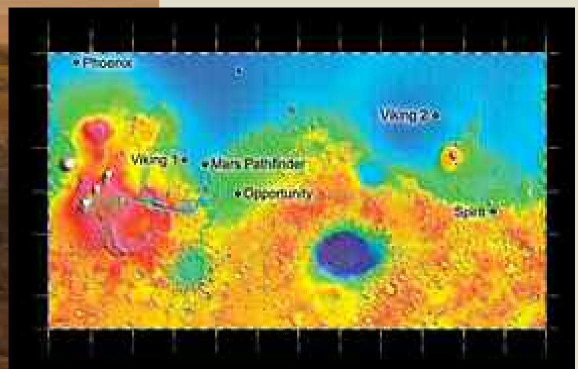
north and south, providing some hope that periodic melting of the near-surface ice offers a habitable zone. A complete analysis of these surface layers to understand the chemistry, mineralogy, and geology of this unexplored environment is the goal of the *Phoenix* mission. Five cameras, from descent imagers to panoramic imagers to microscopes resolving down to the surface structure of a grain of sand, provide the context of our site. Small beakers accept samples provided by our mechanical arm and mix the soil with terrestrial water: saltiness, acidity, and a range of chemical constituents can be determined. Eight ovens accept other samples, which are slowly heated to 1,000 degrees Celsius. Vapors driven out by water release and decomposition are studied in a mass spectrometer.

In these early stages of exploring Mars, we are still ignorant about the polar weather conditions and the changes of climate with season. A meteorology station will record temperature, pressure, and cloud properties throughout our operational phase in the summer of 2008. In particular, we wish to know how the atmosphere and the subsurface ice interact. Humidity and wind direction can give us some idea of how water vapor is transported during the different seasons. Our surface mission is part of a global strategy for exploring Mars, and other landers, rovers, and orbiters allow discoveries to be placed within a regional context.

These goals may seem primitive to future readers, who are likely already far advanced in their knowledge of all things Martian. The world at the turn of the twenty-first century is in a renaissance in space science, medicine, biology, and technology. We have just decoded the human genome, and modern medicines have secured long lives for many of the world's inhabitants. We have visited, or are in the process of robotically visiting, every planet and selected asteroids and comets, even bringing back samples for our laboratory scientists. From the interior of the proton to the unimaginable scope of the universe, the underlying principles and processes are being understood and documented. Each new discovery opens new avenues of investigation; the search



The Phoenix *DVD—containing* Visions of Mars *and the names of a quarter million people who signed up to send their names to Mars—was installed on the deck of the* Phoenix *lander on April 3, 2007 at the Multipurpose Test Facility at the Lockheed Martin Wateron Plant in Denver, Colorado.* Photo: NASA/JPL/Lockheed Martin



The planned landing site for Phoenix *lies at a latitude on Mars equivalent to that of northern Alaska on Earth. This map of Mars, acquired by the Mars Orbiter Laser Altimeter on board* Mars Global Surveyor, *marks the landing site for the* Phoenix *lander in relation to other landers already on the surface of Mars.* Image: NASA/JPL

for Truth continues.

Are the readers of this disk a continuation of this noble endeavor? That would mean that we are of the same culture, and perhaps my children or grandchildren are involved. Otherwise, you may be from an indeterminate future. If it is thousands of years from now, then we may have no common language. America will be in the realm of ancient history, and technology will have radically developed. Future technology would mystify us just as a laptop computer would have had no meaning to Attila the Hun. The discovery and decoding of this disk may be a surprise window into an ancient time. Today's world civilization will have vanished, leaving few clues to its complexity in a distant future, This disk, however, protected from the rapid decay on Earth, may still be in pristine condition.

As our team puts our shoulders to the task of sending a mission to Mars, we have created something of lasting value for society. Members of our *Phoenix* group come from far and wide. Scientists from around the world, assembled at the University of Arizona during the mission, have contributed their experience and knowledge. The Jet Propulsion Laboratory has managed the mission, and Lockheed Martin, the world's largest aerospace company, built the spacecraft. Other countries also have contributed: Canada is building a complex lidar for studying clouds and a weather station, Germany is helping with the camera systems, Switzerland built the first atomic force microscope to fly in space, and Denmark added magnets and a wind sensor. Nearly 300 people have worked on this endeavor: scientists, engineers, managers, and technicians. The level of skill and depth of experience is exceptional.

Representing this diverse team, I salute you future astronauts and wish you good fortune in your explorations. We trust that the small contributions from the *Phoenix* mission have helped you on your path.

Peter Hollingsworth Smith is the principal investigator for Phoenix*, set to land on Mars on May 25, 2008.*

Annual Report to Our Members

Dear Planetary Society Members, Donors, and Friends,

Please join me as I look back at The Planetary Society in fiscal year 2007—October 1, 2006 through September 30, 2007.

During the year, I became Chair of The Planetary Society Board of Directors, and my friend and colleague, Neil deGrasse Tyson, accepted the mantle of President. The year ended on the cusp of the 50th anniversary of *Sputnik*, the craft that marked the launch of the Space Age, and the year of my birth as well.

Growing up, I avidly followed the great milestones of space—*Mercury, Gemini, Apollo, Mariner*s—they kindled a passion that burns brighter than ever today. As we cross the threshold of the "next" Space Age, I am inspired by missions too numerous to name in this space. Yet, I cannot resist mentioning *Phoenix*—soon to touch down on the Martian arctic with your names and the Society's *Visions of Mars* library aboard.

I joined The Planetary Society, Earth's largest citizen organization of space advocates, to be part of this adventure. Whether it is fighting for a robust program of exploration, or to "Save Our Science," or seeking ways to protect our own home planet from asteroids, together, you and I are helping to shape the future.

Into the Future

The Planetary Society is well into its third decade. We are as nimble and fearless as when Carl Sagan, Bruce Murray, and Louis Friedman launched the Society.

After more than 25 years, in the midst of growing concern over Earth and, too often, an alarming misconception about the value of space exploration, we made a small yet vital change to the Society mission statement. Calling attention to our own planet, our mission now reads: "To inspire the people of Earth to explore other worlds, *understand our own*, and seek life elsewhere." We began advocating important Earth observation missions while continuing to advocate for the exploration of Europa and other outer solar system worlds.

No matter what may be your opinion of Pluto's status, Earth is unquestionably a planet, and seeing our home planet as one among many—as different from and similar to the others—is crucial to understanding our "pale blue dot" of a world. We are, we believe, members of the solar system community—Planetary Citizens. It's up to us to push the frontier of space exploration.

Innovation, Excitement, and Adventure—Our Projects

The year saw new projects unveiled, sustenance provided for long-running endeavors, and additional support for future initiatives.

- Your voice for exploration remained strong as part of our continuing "Save Our Science!" campaign. You signed petitions and helped fund our advocacy and public information work. It paid off: Congress listened and restored science funds, and The Planetary Society also helped forestall the closing of the Arecibo Observatory.
- You gave generously to our SETI projects in both hemispheres. First is The Planetary Society Optical SETI telescope operated by Harvard University's Paul Horowitz in Massachusetts, with a search you can now literally follow on The Planetary Society website via a live view of the night sky in the region where the telescope is searching. You also supported the inauguration of SERENDIP V, a radio SETI search operated by Guillermo Lemarchand in Argentina that is targeting the center of the Milky Way and will listen for signals emanating from masers.
- To test the possibility that life could have traveled between planets, our Phobos LIFE (Living Interplanetary Flight Experiment) project will send a collection of living organisms on a three-year journey to the Martian moon Phobos and back to Earth on board the Russian Phobos Soil sample return mission. In a flurry of activity, we have completed the design of our multiple-sealed biocapsule, produced prototypes, held science meetings, studied planetary protection issues, presented our plans at conferences, and considered the science plans and what organisms to send.
- We may yet find an answer to the mysterious *Pioneer* anomaly, a question that gnaws at the laws of physics. Your support enabled the spacecraft data to be "conditioned" so that scientists such as John Anderson and Slava Turyshev of NASA's Jet Propulsion Laboratory can analyze what might be causing the unexplained rate of slowing of the twin *Pioneer*s.
- At your urging and with your support, and with a grant from Discovery Communications, we started work on our solar sail *Cosmos 2*. We have a new launch vehicle and are streamlining the spacecraft design as we continue to seek the full funding needed to set sail. This private space mission will be the first step on our way to interstellar flight. It's an example of our commitment to doing space exploration, not just talking about it.
- The Secure World Foundation partnered with us to develop an "International Lunar Decade" (ILD) to coordinate lunar exploration through a worldwide space agency framework. We made great strides—via presentations and discussions with space leaders and UN committees—en route to official endorsement of such a framework by the world's space agencies. To showcase the need for this crucial work, we produced, with funding from Space Age Publishing, a special lunar issue of *The Planetary Report*.

• We awarded seven Shoemaker NEO Grants to amateur and professional astronomers from Canada, China, Italy, Tahiti, and the United States who are tracking potentially hazardous asteroids. Your support of these modest grants reaps great returns: for example, 2002 Shoemaker Grant recipient Roy Tucker (U.S.) codiscovered the asteroid Apophis.

• The Planetary Society's Apophis Mission Design Competition challenged individuals and teams around the world to design a mission to "tag" a potentially Earth-threatening asteroid like Apophis to make it easier to track. In February 2008, we selected the winners from among a field of nearly 40 contenders.

• Fittingly, we closed one year and launched into the next with The Planetary Society's 2007 Awards Celebration: "Planetary Citizenship in the Next Space Age." Neil deGrasse Tyson presented the Cosmos Award for Outstanding Public Presentation of Science to *NOVA* Senior Executive Producer Paula S. Apsell, and Planetary Society Board Member James Bell presented the Thomas O. Paine Award for the Advancement of Human Exploration of Mars to Michael C. Malin, president and chief scientist of Malin Space Sciences Systems. These awards reaffirmed the Society's commitment to involving you, and others around the world, as active participants in shaping our future in space. *(continued on next page)*

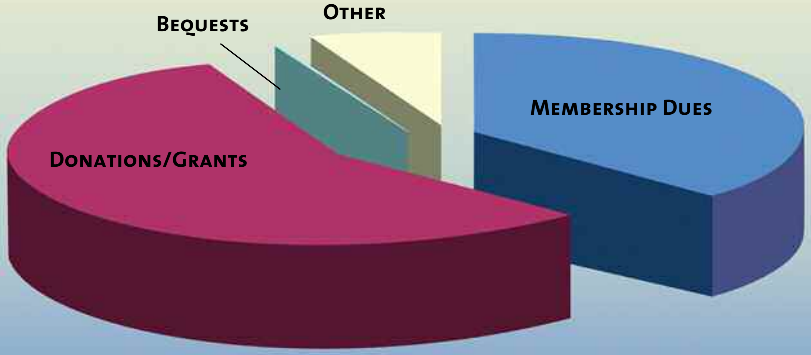
Balance Sheet

For the Fiscal Years Ended September 30, 2003, 2004, 2005, 2006 and 2007 in thousands of dollars.

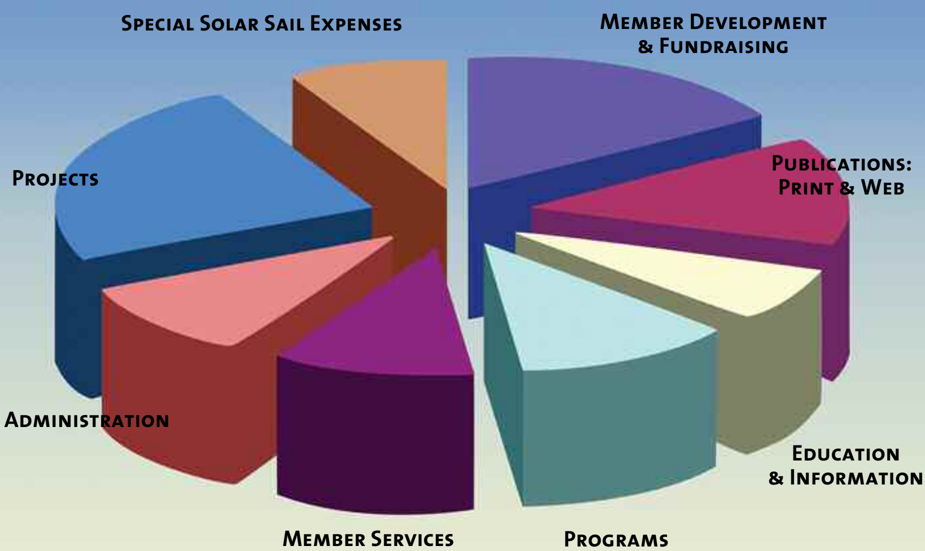
	Total All Funds:				
Assets	**FY2007**	**FY2006**	**FY2005**	**FY2004**	**FY2003**
Current Assets					
Cash and Cash Equivalents and Investments	1,612	1,304	1,511	1,572	1,959
Membership Dues and Misc. Receivables	32	206	277	209	114
Inventories	42	50	64	53	47
Prepaid Expenses	37	26	49	51	21
Total Current Assets	**1,723**	**1,586**	**1,901**	**1,885**	**2,141**
Land, Building, and Equipment	**617**	**655**	**683**	**638**	**658**
Total Assets	**2,340**	**2,241**	**2,584**	**2,523**	**2,7996**
Liabilities	FY2007	FY2006	FY2005	FY2004	FY2003
Accounts Payable and Accrued Expenses	286	195	206	129	101
Deferred Dues and Grant Revenue*	1,134	1,065	1,147	1,247	1,420
Total Liabilities	**1,420**	**1,260**	**1,353**	**1,376**	**1,521**
Net Assets (Deficits)	FY2007	FY2006	FY2005	FY2004	FY2003
Unrestricted	389	633	844	(96)	60
Temporarily Unrestricted	529	346	385	1,241	1,217
Permanently Restricted	2	2	2	2	1
Total Net Assets	**920**	**981**	**1,231**	**1,147**	**1,278**
Total Liabilities and Net Assets (Fund Balances)	**2,340**	**2,241**	**2,584**	**2,523**	**2,799**
Revenues	FY2007	FY2006	FY2005	FY2004	FY2003
Membership Dues	1,212	1,299	1,366	1,538	1,636
Donations/Grants	1,835	1,180	1,610	1,230	1,495
Bequests	3	37	72	0	10
Other **	205	396	208	282	258
Solar Sail Grant	0	0	0	0	0
Total	**3,255**	**2,912**	**3,256**	**3,050**	**3,399**
Expenses	FY2007	FY2006	FY2005	FY2004	FY2003
Member Development and Fundraising	534	443	421	380	342
Publications: Print and Web	467	535	554	721	629
Education and Information	228	182	117	121	102
Programs ***	364	432	418	455	551
Member Services	345	338	343	331	312
Administration	305	317	312	338	408
Projects	805	798	579	703	561
Special Solar Sail Expenses	267	117	428	132	228
Total	**3,315**	**3,162**	**3,172**	**3,181**	**3,133**

* Income received but not yet recognized ** Admissions, interest, net sales, royalties, etc. *** Events, lectures, tours, and expeditions

Fiscal Year 2007 Revenues



Fiscal Year 2007 Expenses



Your Investment Pays Off

The Planetary Society continues to do great things, but as you can see by our balance sheet, membership revenue is decreasing even as renewals remain high and donations rise. In response, we are sharpening our outreach. We continue to seek new ways to involve people in The Planetary Society. The Weissman Family Foundation enabled Society Vice President Bill Nye the Science Guy® to address the Space Generation conference at the International Astronomical Union meeting in India.

We are spreading the word about how ordinary citizens the world over—Planetary Citizens—can get involved via web features and The Planetary Society blog and over the airwaves with Planetary Radio. A grant from the Kenneth T. and Eileen L. Norris Foundation enabled us to debut a monthly Sally Ride Science segment on the radio show, and this year, again thanks to a Norris Foundation grant, Bill Nye delights listeners with weekly space exploration commentary.

At the end of the day it is you, our loyal supporters, who provide us the means by which these projects are possible. Introduce a friend, relative, or coworker to The Planetary Society. Please consider The Planetary Society in your estate planning. Many of you have already told us of your plans, and we are grateful for your future gifts. Society members help in many ways—with gifts of securities, matching gifts from their employers, and donations of time and expertise.

Finally, give the gift of membership to the young people in your life and help to revitalize enthusiasm for space and science in the fertile minds that will shape our future.

As Bill likes to say, "I'm just trying to change the world." That's also what you and I are doing. Thank you for helping The Planetary Society change the world.

Sincerely yours,

Dan Geraci
Chair, Board of Directors

Dan Geraci is chair of The Planetary Society's Board of Directors and a member of the Society's New Millennium Committee. He is also chairman and CEO of Club Achilles Luxury Indoor Golf Clubs based in La Quinta, California.

World Watch

Washington, D.C. —The administration's proposal for NASA's fiscal year 2009 (beginning in October 2008) budget showed significant increases for space and Earth science funding, with one remarkable exception: Mars.

First, the good news. Responding to the recommendations of the U.S. National Research Council, the administration proposed two new Earth-observing satellites. *ICESat II*—the *Ice, Cloud, and Land Elevation Satellite*—will be a second-generation spacecraft that specializes in measuring ice-sheet mass and will also map topography and vegetation. *SMAP—Soil Moisture Active/Passive*—will monitor moisture in the soil and freeze-thaw cycles.

The National Oceanic and Atmospheric Agency also received a boost in funding, with restoration of some of the cuts for the troubled *National Polar-Orbiting Operational Environmental Satellite System* as well as for other Earth-monitoring satellites.

The new budget includes funds for NASA to start an outer planets flagship mission, either to Jupiter's moon Europa or to Saturn's moon Titan. Details about the mission and its destination will be announced later this year. The House Appropriations Committee has pushed a Europa orbiter for the past two years, and The Planetary Society has been a strong supporter of a Europa mission. We congratulate NASA on the commitment to an outer planets mission.

Three relatively small lunar missions also made it into the proposed science budget. An orbiter designed to study dust concentrations above the Moon's surface is scheduled for 2011, and a pair of landers—one headed to the Moon's north pole and the other toward the south pole—is planned for 2013 or 2014.

The bad news in the budget is the impact on the Mars program. The program's total budget was cut by 35 percent—nearly $200 million! The science orbiter planned for 2013 has been postponed indefinitely (although NASA says it can be reconsidered for a 2016 launch). Planning for the astrobiology lander/rover scheduled for 2016 also was canceled. These setbacks come in addition to the recently announced delay of the 2011 Scout mission until 2013.

Another budget blow is the recent admission by JPL that development of the entry, descent, and landing system for the *Mars Science Laboratory* is proving much more difficult than anticipated. The project requires an addition of nearly $200 million to keep development on track for a 2009 launch.

The U.S. Congress will hold hearings on the budget this spring and attempt to pass the fiscal year 2009 budget before the presidential elections this fall. The Planetary Society has sent a letter about the Mars budget cuts to its representative on the House Appropriations Committee and submitted testimony to congressional committees in charge of considering the NASA budget. —*LDF*

Special Report: Europe Heading Toward the Moon and Mars

by Risto Pellinen

In November 2007, Germany announced plans to construct a national Lunar Exploration Orbiter to be launched in 2012. The spacecraft would orbit at 50 kilometers (35 miles) above the lunar surface, conducting high-resolution 3-D color imaging, gravity and geological measurements, and testing optical communication. The political decision to go ahead with the mission—which will cost about 300 million euros—is expected in 2008.

Parallel to Germany's effort, the United Kingdom is considering a lunar telecommunications orbiter, called *MoonLITE*, which would carry four penetrators to be deployed two meters into the surface. The main scientific goals would be to examine below the lunar surface and to study the Moon's interior by using seismic methods. The launch is scheduled no earlier than 2012, and the mission will cost 200 to 300 million euros.

Since *SMART-1* impacted the lunar surface in 2006, the European Space Agency (ESA) has had no planned missions to the Moon. ESA has supported the Indian *Chandrayaan-1* mission with some payload contributions, has assisted in getting the Chinese *Chang'E-1* into lunar orbit, and is closely following Japan's plans for its next steps in lunar exploration.

ESA's main contribution to exploration is in the ExoMars program, now funded for 2008 with 80 million euros. The entire mission, to be launched in 2013 and costing slightly more than 1 billion euros, is expected to be approved by the ESA Ministerial Council in late 2008. The mission consists of a rover with a 16.5-kilogram (36.5-pound) Pasteur payload and an 8.5-kilogram (18.5-pound) Geophysics Environmental Package (GEP) surface station. There is a possibility of U.S. and Russian cooperation in ExoMars.

ESA is also preparing for the Mars Sample Return (MSR) mission planned for the early 2020s and is considering a technology demonstration mission (NEXT) after ExoMars and before MSR.

Russia aims to launch the *Phobos-Grunt* mission in 2009. Besides the probe that will land on Mars' moon Phobos and the carrier that will bring samples back to Earth, the mission will carry a Chinese 110-kilogram (242-pound) Martian orbiter (*Yinghuo-1*) and one or two Finnish MetNet meteorological stations to be deployed on the Martian surface. Recently, Russia has agreed to join forces with India to take an orbiter, lander, and rover to the Moon in 2013.

Risto Pellinen is director of Science in Space Research at the Finnish Meteorological Institute, is a member of The Planetary Society's International Council, and served as head of ESA's Science Programme Committee.

We Make It Happen!

by Bruce Betts

Planetary Society Names Winners of $50,000 Asteroid Tagging Competition

How do you tag and track an asteroid that might be on a collision course with Earth? That's the question we asked in The Planetary Society's $50,000 Apophis Mission Design Competition. Proposers were challenged to design a mission to rendezvous with and "tag" a potentially dangerous near-Earth asteroid, using the asteroid Apophis as the example. Tagging would allow scientists to track an asteroid accurately enough to determine whether it will impact Earth, thus helping governments decide whether to mount a deflection mission to alter its orbit.

We received 37 mission proposals from 20 countries on 6 continents. We were thrilled with the quality of the entrants, and in February 2008, we announced the winners.

The Envelopes, Please

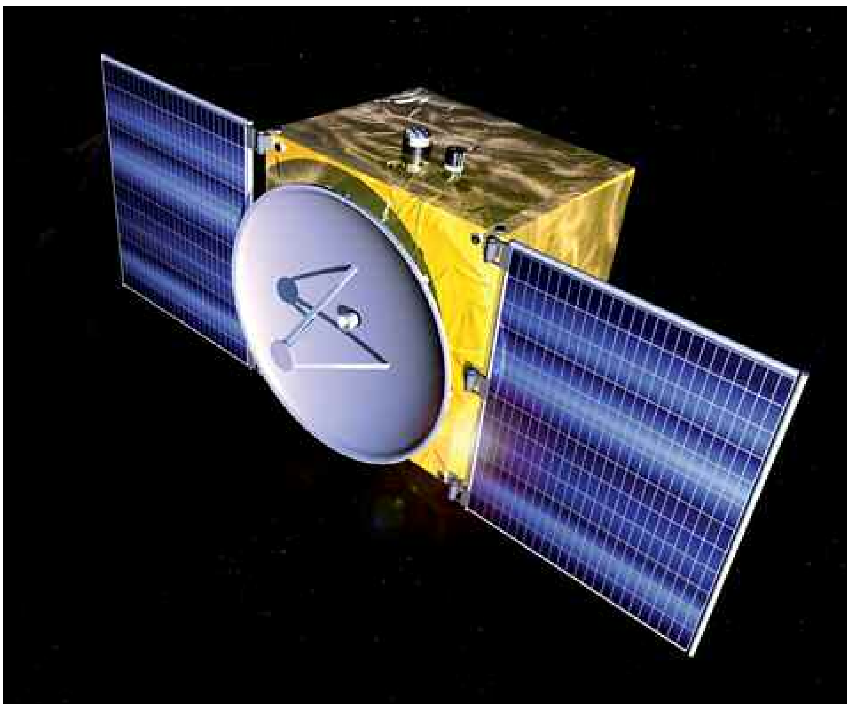
The $25,000 first-place prize went to the team led by SpaceWorks Engineering, Inc., of Atlanta, Georgia in collaboration with SpaceDev, Inc., Poway, California for their mission, titled *Foresight*. To keep mission costs low, they proposed a simple orbiter with only two instruments and a radio beacon, totaling $137.2 million. The *Foresight* orbiter would circle the asteroid to gather data with a multispectral imager for one month. It would then leave orbit and fly in formation with Apophis around the Sun at a range of two kilometers (1.2 miles). The spacecraft would use laser ranging to the asteroid and radio tracking from Earth for 10 months to accurately determine the asteroid's orbit and how it might change.

Second place and a prize of $10,000 went to a team led by Deimos Space S.L. of Madrid, Spain, in cooperation with EADS Astrium, Friedrichshafen, Germany; University of Stuttgart, Germany; and Universitá di Pisa, Italy.

Another European team took home $5,000 for third place. That team's lead was EADS Astrium Ltd, United Kingdom, in conjunction with EADS Astrium SAS, France; IASF-Roma, INAF, Rome, Italy; Open University, UK; Rheinisches Institut für Umweltforschung, Germany; Royal Observatory of Belgium; and Telespazio, Italy.

You can find summaries of all the winning proposals, as well as the full proposals, online at *planetary.org/apophis*.

Special awards went to several student teams. The Georgia Institute of Technology team took first place in the student category, winning $5,000. Two student teams—one from Monash University, Australia and the other from the University of Michigan—tied for second place, each receiving $2,000. A group from Hong Kong Polytechnic University and Hong Kong University of Science and Technology received an honorable mention and $1,000 for the most innovative student proposal.



***Foresight**, the winning entry in The Planetary Society's Apophis Mission Design Competition, is a small, low-cost spacecraft.* *Illustration: SpaceWorks/SpaceDev for The Planetary Society's Apophis Mission Design Competition*

Moving Forward

The competition succeeded not only in producing viable proposed mission designs but also in bringing more attention to the threat of near-Earth objects (NEOs). On any given day, we are likely safe from falling space rocks, but one day, an asteroid will have Earth's name on it, and it is the one natural disaster that we can prevent—if we do our homework ahead of time.

We hope the winning entries will catalyze the world's space agencies to move ahead with designs and missions to protect Earth from potentially dangerous asteroids and comets. NASA and the European Space Agency (ESA) co-sponsored The Planetary Society's competition and will review the best mission designs offered. The winning designs also will be presented by The Planetary

Society to other world space agencies.

The Planetary Society conducted the Apophis Mission Design Competition in cooperation with NASA, ESA, the Association of Space Explorers (ASE), the American Institute of Aeronautics and Astronautics (AIAA), and the Universities Space Research Association (USRA).

The Apophis Mission Design Competition is part of the Society's year-long program—Target Earth—to mark the 100th anniversary of the Tunguska event, when an exploding asteroid or comet leveled 2,000 square kilometers of Siberian forest in June 1908. Target Earth will focus on a variety of NEO projects supported by The Planetary Society, which include the Apophis Mission Design Competition, the Shoemaker Near Earth Objects Grants, science and exploration mission advocacy, and a one-hour HDTV *Daily Planet* special on asteroids that is being produced by Discovery Canada.

Bruce Betts is director of projects for The Planetary Society.

This is how asteroid Apophis may look as it approaches Earth, first in 2029 and again in 2036. *Illustration: Dan Durda*

Special Thanks

We express special thanks to Dan Geraci, The Planetary Society's Chairman of the Board, who contributed $50,000 to the Apophis competition, and to all Planetary Society members who contributed the additional funding needed to make this competition happen. Our thanks go as well to the very talented and busy members of our review panel: Mark Adler, JPL; Ian Carnelli, ESA; Daniel D. Mazanek, NASA Langley; Naomi Murdoch, ESA; Stefano Santandrea, ESA; and Simon "Pete" Worden, NASA Ames.

What's Up?

In the Sky— April and May 2008

In the early evening sky, two planets are high overhead: orange-red Mars in Gemini and yellowish Saturn in Leo. They appear to grow closer as the weeks pass. In the predawn eastern sky, Jupiter is the very bright starlike object in the southeast. The Moon will appear close to it on May 24.

Random Space Fact

The Earth-Moon distance (about 384,000 kilometers, or about 240,000 miles) would easily fit within the diameter of the Sun (about 1.4 million kilometers, or 0.9 million miles).

Trivia Contest

Our November/December contest winner is Chad Reiman of Patterson, Missouri. Congratulations!

The Question was: NASA's *Dawn* spacecraft launched September 27, 2007. What two asteroids is it scheduled to visit and orbit? *The Answer is*: Vesta and Ceres.

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

What is the approximate altitude of a geostationary satellite (one that stays over one point of the equator all the time, frequently used for things like satellite TV and communications)?

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 June 1, 2008. The winner will be chosen by a random drawing from among all the correct entries received.

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

Questions and Answers

What percentage of Pluto do mission planners expect to image during the* New Horizons *flyby? I assume the mission plan gives* New Horizons *one shot at imaging the Pluto system.
—Robert C. Gorby
Santa Ana, California

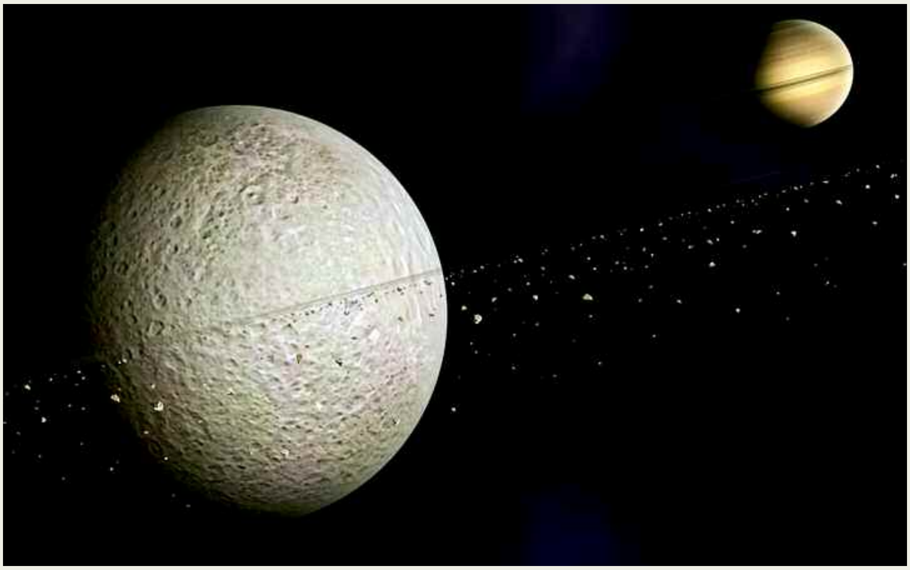
Our ability to map Pluto's surface comprehensively is limited by several factors, including the resolution of our cameras, our rate of approach, and the direction of solar illumination. The most fundamental constraint is that at the time of the *New Horizons* flyby, in July 2015, the Sun will be 49.4 degrees south of the equator, which means that only 83 percent of Pluto will be illuminated during the course of a Pluto day. We will image all of this sunlit 83 percent, but our coverage will be far from uniform.

New Horizons approaches Pluto at a rate of 1.2 million kilometers per day, and Pluto takes 6.4 days to rotate once on its axis, so roughly half of Pluto will be best seen 3.2 days before closest approach, at a range of 3.6 million kilometers. At this range, our highest-resolution camera, the Long-Range Reconnaissance Imager (LORRI), will take pictures with a resolution of 18 kilometers per pixel. Thus, our best images of this side of Pluto will be about 130 pixels across. This is still a dramatic improvement over our current best images of any part of Pluto, taken by the Hubble Space Telescope, which are only 3 or 4 pixels across.

Near closest approach, we will image about 40 percent of Pluto at 670 meters per pixel (producing an image 3,500 pixels across!), and smaller fractions of the surface will be photographed at even higher resolution. Of the remaining 17 percent—Pluto's winter hemisphere, which will never see the Sun at the time of the *New Horizons* flyby—half will be on the side that always faces Pluto's moon Charon and, therefore, will be dimly illuminated by Charon. We will make some long-exposure images of this moonlit north polar region, but the quality of those images will be low compared to the sunlit pictures.

So, to summarize, we will image about 40 percent of Pluto in sunlight at the very high resolution of 670 meters per pixel, 43 percent in sunlight at various lower resolutions, and up to 9 percent, near the winter pole, very dimly in Charon's light. About

Factinos



Saturn's second largest moon, Rhea, is heavily cratered and lies outside the giant planet's main ring system. Recent* Cassini *observations have detected a decrease in the number of electrons on both sides of the moon. Scientists suggest that rings are the likeliest cause of these electrons being blocked before they reach the spacecraft. The suggested rings are illustrated here, but their density has been exaggerated for clarity.
Illustration: NASA/JPL/Johns Hopkins University, Applied Physics Laboratory

Rhea, Saturn's second-largest moon, may have rings. If so, this would the first time rings have been found around a moon. A suite of six instruments on *Cassini*, specifically designed to study the atmospheres and particles around Saturn and its moons, has detected a broad debris disk and at least one ring around Rhea.

"Until now, only planets were known to have rings, but now Rhea seems to have some family ties to its ringed parent, Saturn," said Geraint Jones, of the Mullard Space Science Laboratory, University College, London, and lead author of a paper that appeared in the March 7, 2008 issue of *Science*.

Rhea is roughly 1,500 kilometers (950 miles) in diameter. The apparent debris disk measures several thousand miles from end to end. The particles that make up the disk and any embedded rings probably range from the size of small pebbles to boulders. An additional dust cloud may extend up to 5,900 kilometers (3,700 miles) from the moon's center, almost eight times the radius of Rhea.

Since the discovery, *Cassini* scientists have performed numerical simulations to determine if Rhea can maintain rings. The models show that Rhea's gravity field, in combination with its orbit around Saturn, could allow rings that form to remain in place for a very long time.

"Like finding planets around other stars, and moons around asteroids, these findings are opening a new field of rings around moons," said *Cassini* team member Norbert Krupp, from the Max Planck Institute for Solar System

8 percent of the surface will be in complete darkness throughout the flyby (not counting moonlight from the newly discovered moons Nix and Hydra, which is too faint to be of any use to us) and will have to wait for the next Pluto mission.
—JOHN SPENCER,
Southwest Research Institute

Is anyone searching for extraterrestrial life that is not based on water? If not, why not?
—Trace Bissinger
Pendleton, Oregon

Scientists interested in the search for extraterrestrial life are open to all possibilities. The *Viking* mission to Mars offered the first opportunity to search for life on the Martian surface. The main focus of the three biology experiments was carbon/water-based life, and all three gave negative results. The landers' cameras, however, could have detected any life-form based on any chemistry, provided that it was large enough to produce visible tracks, burrows, waste dumps, artificial structures, or motion, and that it was kind enough to do so in the immediate vicinity of the landers. Carl Sagan and Joshua Lederberg, among others, investigated the camera images in great detail but found no signs of life.

We used to joke that if one of the many rocks in the scene started moving around, we would conclude it was alive, even if we didn't understand what kind of life it was. No rocks moved. Similarly, the people who search for radio signals for life from planets circling distant stars would be just as thrilled to get a message from life-forms based on some element other than carbon and using a solvent other than water. The radio search is completely independent of the composition of the beings that send the message.

That said, we see real advantages of water for life. It is the second most abundant compound in the universe, after H_2. It is a remarkably good solvent, and it stays liquid over a large range of temperatures. This range is ideal for the broad variety of chemical reactions that produce the complex carbon-based molecular structures that can store and transmit the information necessary for matter to become life.

Carbon is the fourth most abundant element in the universe. With other elements, it readily forms highly complex molecules, creating rings and chains that provide skeletons for those intricate structures capable of saving and transmitting the information that allows matter to be alive. No other element even comes close to carbon in this respect.

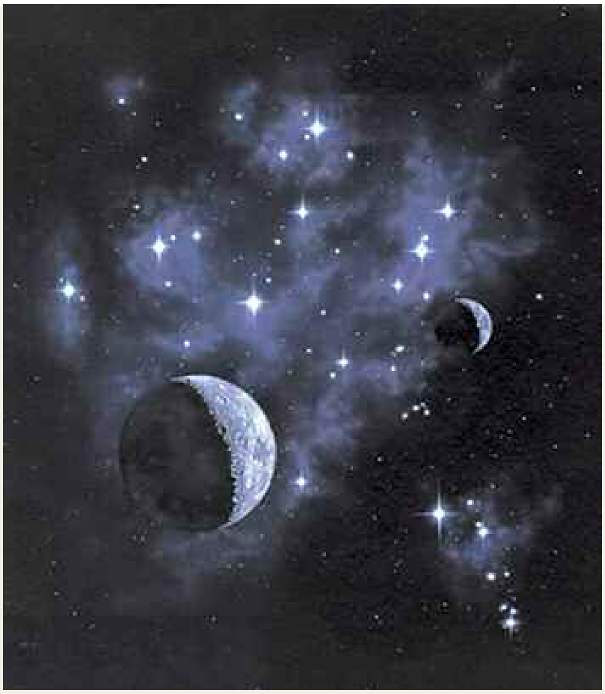
Silicon is often proposed as a substitute, but silicon has a fatal attraction for oxygen that leads to the formation of rocks. That doesn't mean other carbon-based life-forms will look like us, but it does mean that other life in the cosmos probably is based on carbon. Even if it isn't, we will still love it!
—TOBIAS OWEN,
University of Hawaii

Research in Katlenburg-Lindau, Germany.
—from the Jet Propulsion Laboratory

Terrestrial planets might form around many, if not most, of the nearby Sun-like stars in our galaxy, reports Michael Meyer of the University of Arizona and his team. Their new findings suggest that worlds with potential for life might be more common than we thought. Meyer and his colleagues used the Spitzer Space Telescope to determine whether planetary systems like ours are common or rare in our galaxy. They found that at least 20 percent, and possibly as many as 60 percent, of stars similar to the Sun are candidates for forming rocky planets.

The researchers used Spitzer to survey six sets of stars, grouped depending on their age with masses comparable to our Sun. "We wanted to study the evolution of the gas and dust around stars similar to the Sun and compare the results with what we think the solar system looked like at earlier stages during its evolution," Meyer said.

"We found that about 10 to 20 percent of the stars in each of the four youngest age groups show 24-micron emission due to dust," he said. "But we don't often see warm dust around stars older than 300 million years. The frequency just drops off. That's comparable to the time scales thought to span the formation and dynamical evolution of our own solar system," he added. Theoretical models and meteorite data suggest that Earth formed over



Scientists using the Spitzer Space Telescope have discovered that at least 20 (and perhaps as many as 60) percent of nearby Sun-like stars have terrestrial planets around them. This rocky planet and its moon near a large star-forming region are illuminated by their parent star, out of frame at upper right.
Illustration: Dan Durda

a span of 10 to 50 million years as a result of collisions between smaller bodies, he noted.

The team published its results in the February 1, 2008 issue of *Astrophysical Journal Letters*.
—from the University of Arizona

For more detail on these stories, visit *planetary.org*.

Society News

Sir Arthur C. Clarke, famed science fiction author and longtime member of The Planetary Society's advisory board, died on March 18, 2008 at the age of 90.

Remembering Arthur C. Clarke
by James D. Burke, Technical Editor of *The Planetary Report*

Sir Arthur C. Clarke, who died on March 18, was an admired friend whose world reputation never interfered with his lively interest in everything, be it a product of his remarkable imagination or just some event that piqued his interest. Throughout his long life he displayed a childlike delight in finding out new things and sharing his joy in that with others—or, lacking new things to find at the moment, inventing new things that might someday be found.

Armed with that nimble mind and unencumbered by convention, he would have been a successful innovator if all he had done was to pursue an electrical engineering career, where, among other things, he called attention to the possibility of geosynchronous communications satellites. But in his classic 1945 paper in *Wireless World*, he already showed his visionary side. Instead of imagining what has actually happened, robots handling floods of information in a huge new industry, he pictured something much more radical—people living out there and operating the vast relay stations as people do now when they manage big power plants on Earth.

This ability to leap beyond today's perceived limits was greatly amplified by the talent of a gifted storyteller. Time and again, in reading a Clarke tale, you come to a zinger in the last sentence, and earlier you may have been moved to tears by his knowledge of humanity and compassion for sentient creatures, wherever they may be.

One of my favorite Clarke anecdotes originated at our own dinner table. Sir Arthur, having become founding chancellor of the International Space University and musing on the Renaissance and the Enlightenment, remarked that the founding of Europe's great universities coincided with the beginning of transocean navigation.

Always, right to the end of his days, he was looking out ahead.

A Stamp for Carl

Members might enjoy knowing about the interest that has been generated in a U.S. postage stamp honoring my brother, Carl Sagan. Like The Planetary Society itself, this is a citizen-driven, grassroots movement, started by the Sciencecenter in Ithaca and the Sagan Appreciation Society in Utica, New York. To create a postage stamp, the process is long, and it requires public interest and involvement. I would consider it a personal favor if Members of The Planetary Society would take the time to snail-mail a letter to the U.S. Postal Service stating why you think it would be a good idea to honor Carl in this way. Your letters don't have to be long, just enthusiastic!

Should any members wish to participate, please send a letter to: **Citizens' Stamp Advisory Committee, c/o Stamp Development, U.S. Postal Service, 1735 North Lynn St., Suite 5013, Arlington, VA 22209-6432.**

Please send a duplicate letter to: **Citizens' Stamp Advisory Committee, c/o Stamp Management, U.S. Postal Service, 475 L'Enfant Plaza, SW, Room 4474 EB, Washington, DC 20260-6756.**

Thank you!
—CARI SAGAN GREENE,
League City, Texas

Members' Dialogue

Human Exploration

I am once again baffled that the board of The Planetary Society doesn't understand that all space exploration is "human" space exploration. Telescopes and robotic probes do not explore space. It is the humans controlling them and analyzing the data they return who explore space. I think it is time we learn to dissociate the notion of human exploration from the notion of human spaceflight. Human spaceflight today is unnecessary for space exploration. Human spaceflight is, in fact, nothing more than a sickening waste of money.

When Congress adds provisions to the appropriations bill to prevent the administration from spending money on human spaceflight, The Planetary Society should support that, not fight it. It is easy to see that the scientific return from many unmanned missions would far exceed the scientific return from even a very successful human Mars expedition.

Isn't promoting exploration of space the main objective and vision of The Planetary Society? Then let's do that! The administration has wasted enough money, time, and other resources on human spaceflight. Let's help them to actually explore space—using telescopes and unmanned probes.
—HANS K BUHRER,
Smithsburg, Maryland

Please send your letters to
Members' Dialogue
The Planetary Society
65 North Catalina Avenue
Pasadena, CA 91106-2301
or e-mail: *tps.des@planetary.org*

MARS BECKONS!

NEW! Commemorative Mars Marble Key Fob

We're going to Mars! The names of a quarter-million people—including all Planetary Society members—are on the way to Mars on board the *Phoenix* spacecraft, which launched in August 2007.

Our Mars replica key fob is emblazoned with the words "I'm Going Here!" with an arrow pointing to the Martian north pole. Don't miss your chance to get this commemorative Mars marble key fob, which features:

- 1-inch-diameter Mars marble made from recycled glass
- Geographic details, including white polar caps, dark canyons, mountains, and volcanoes
- Silver-plated hardware allowing Mars to spin freely

1 lb. **#605** **Regular price: $6.39** **Member price: $5.75**

An Explorer's Guide to Mars Poster

Images from *Mars Global Surveyor,* speculative paintings of the Red Planet's past and future, informative captions and charts, and images of Mars' surface from the *Pathfinder* and *Viking* spacecraft enhance a detailed U.S. Geological Survey map. 24" x 37" 1 lb. **#505**
Regular price: $16.95 **Member price: $15.25**

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**
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12" x 30" 1 lb. **#326**
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Set Sail for the Stars! Poster
22" x 34" 1 lb. **#571**
Regular price: $15.00 **Member price: $13.50**

Pathfinder Images of Mars
20 slides. 1 lb. **#215**
Regular price: $8.34 **Member price: $7.50**

"Is Anyone Out There?" T-Shirt
Adult sizes: S, M, L, XL, XXL 1 lb. **#586**
Regular price: $22.17 **Member price: $19.95**

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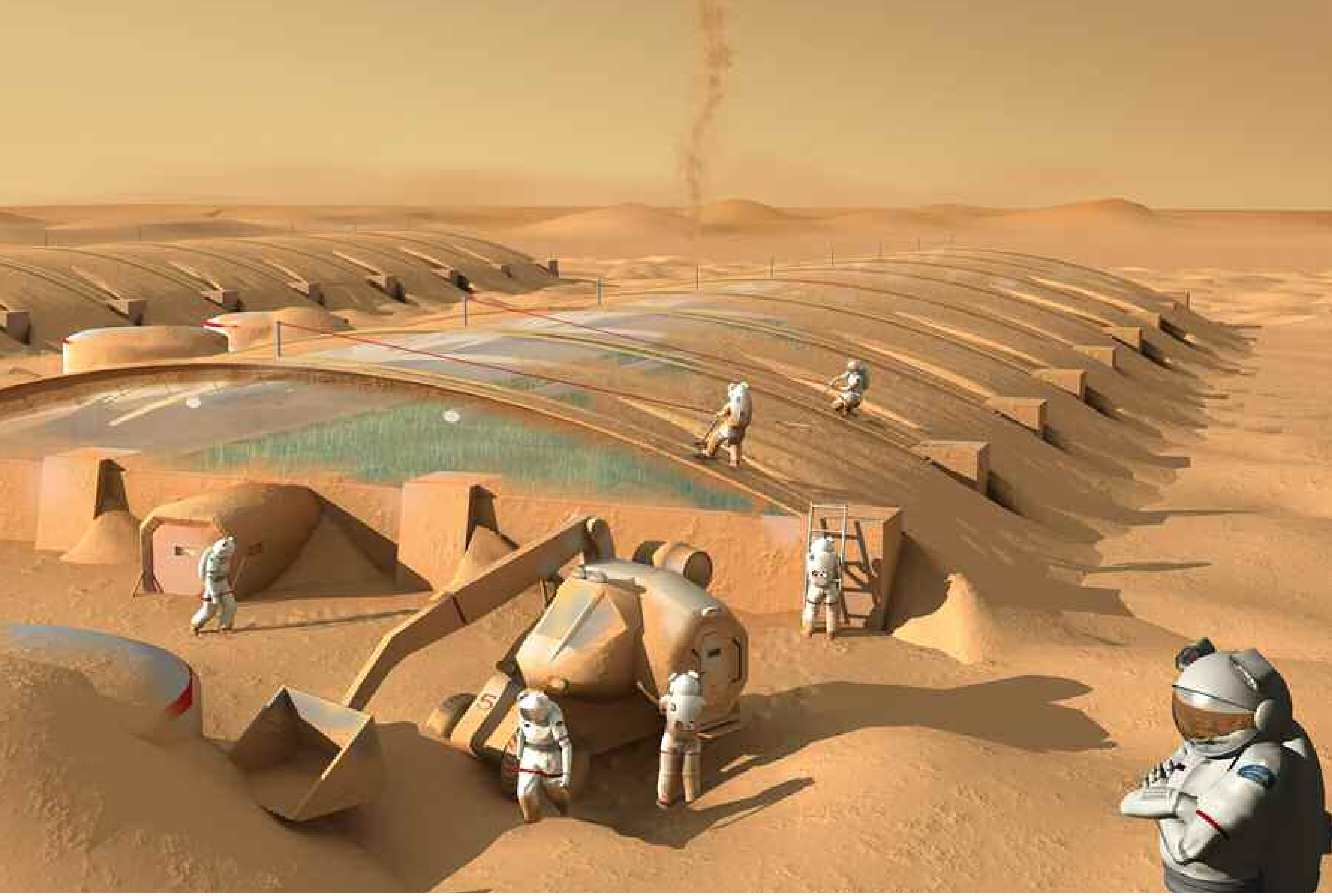

"Dear Dad:
The sandstorm has finally ended. Despite Mars' lower gravity, the weight of drifting sand is still problematic on our more delicate structures. As you can see, we are starting the cleanup on the greenhouses. Talk to you soon."

After the Storm by Raymond Cassel is the grand prize winner of the National Space Society's Space Settlement 2009 Calendar Art Contest.

Raymond Cassel is an industrial designer and illustrator. He has worked in a variety of industries that include aviation, telecommunications, medical equipment, science education, and the nonprofit sector. The majority of Ray's fine art work focuses on wildlife, in which he uses traditional paints and brushes in contrast to his professional design work.

THE PLANETARY SOCIETY
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Printed in USA