The PLANETARY REPORT

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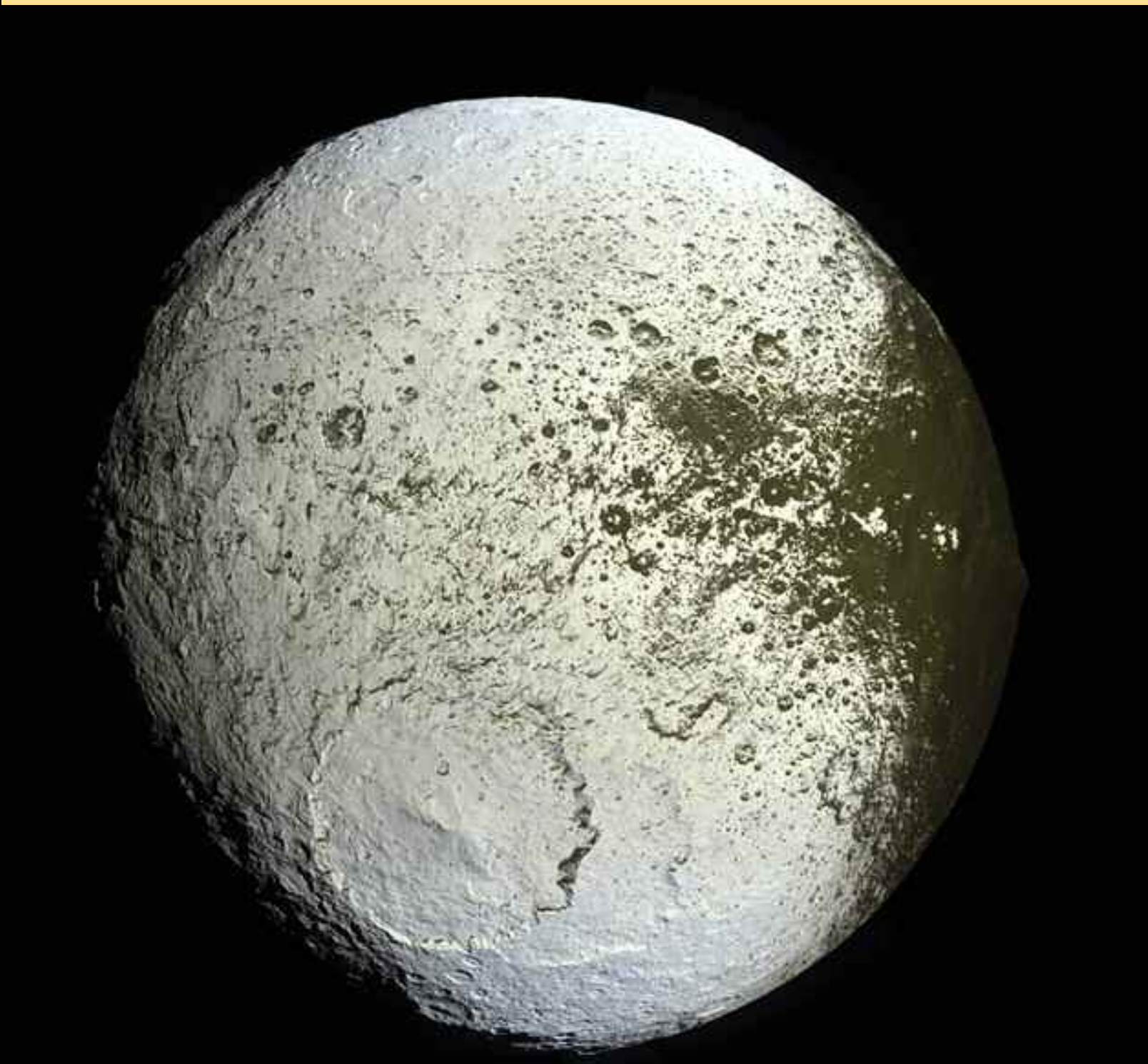

Portraits from Our Solar System

From The Editor

"To see the Earth as it truly is, small and blue and beautiful in that eternal silence where it floats, is to see ourselves as riders on the Earth together. . . ."

Those words by Archibald MacLeish, written for *The New York Times* about the *Apollo* program, have guided the careers of many of us who were children during the Moon landings and then turned our mature energies and talents to understanding that small planet and the worlds that share its neighborhood.

In the years since *Apollo*, you and I have seen space exploration falter, recover, and grope for a way forward. As riders on the Earth together, we once had the will and the power to take that first step to new worlds, but in many ways we are farther from Mars now than we were in 1972, when the astronauts left their last footprints on the Moon.

In the years between, you and I have watched as scientists and politicians have been forced to realize that the planet that launched *Apollo* is small, delicate, and vulnerable. The technologies that powered us to the Moon have also given us the power to change our planet. Unfortunately, with power, wisdom does not always follow.

The time has come for you and I, as riders on the Earth together, to find new ways to explore and act and work together. Planetary Citizenship, a program we are developing and announce in this issue, bring you and me together to better this pale blue dot of ours.

—*Charlene M. Anderson*

On the Cover:

Why one side of Iapetus is dark and the other side is bright has been a mystery since Giovanni Domenico Cassini discovered this Saturnian moon more than 300 years ago. Cassini's namesake spacecraft is now exploring the Saturn system on a primary mission that will include nearly 80 orbits of Saturn. *Cassini* swings by Titan on more than half these orbits and has frequent reasonably close encounters with most of the other moons. Iapetus orbits Saturn at three times Titan's distance, so *Cassini* had only one chance—on September 10, 2007—to swing out on a specially planned, highly elliptical distant orbit and view the yin-yang moon up close.

This global portrait of the bright side of Iapetus shows the complexity of the boundary between the bright and dark material. Close inspection of the image reveals that there is no "gray" on Iapetus; moving from the dark to the bright regions, the dark stain on Iapetus' leading hemisphere breaks up into smaller and smaller patches, concentrated on crater floors and equator-facing crater walls.

Image: NASA/JPL/Space Science Institute

Background:

On the evening of May 19, 2005 (*Spirit*'s 489th Martian day, or sol), mission controllers commanded the rover to stay awake long enough to take this picture of the Sun setting behind the rim of Gusev crater. *Spirit* took this small panorama of the western sky with its Panoramic Camera (Pancam) using a combination of filters that produced a false-color image that emulates what our eyes would see if we were standing on Mars. Image: NASA/JPL/Texas A&M University/Cornell University

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WORLDS BEYOND

BY ANDRE BORMANIS

NASA IS POISED TO RETIRE THE SPACE SHUTTLE AND RETURN ASTRONAUTS TO THE MOON. THE MOON, HOWEVER, ISN'T THE ONLY TARGET SOME SCIENTISTS HAVE IN MIND FOR THE NEXT GENERATION OF SPACESHIPS.

A long time ago, in what sometimes seems like a galaxy far, far away, America did something astonishing. We strapped groups of men, three at a time, atop immense, fire-belching rockets and sent them hurtling to the Moon.

It's hard to believe, but 35 years have passed since *Apollo 17*, the last of the manned lunar excursions. Nearly 40 percent of the current American population wasn't alive when its crew bid farewell to the Moon. The surviving *Apollo* astronauts are well into retirement.

But now NASA has a serious plan to return humans to the Moon. Generations X, Y, and Z finally will get their chance to see human beings explore another world. It's about time.

New Plans

Like most space buffs who vividly remember the *Apollo* missions, I am tremendously excited by this new initiative. By presidential directive, NASA is once again on a path of exploration. The space shuttle will be retired in 2010 and eventually replaced by a vehicle called *Orion*. It strongly resembles the venerated *Apollo* Moon ship: a ballistic capsule capable of carrying astronauts beyond low Earth orbit (LEO) and returning them to Earth. Congress, so far, supports the plan.

My enthusiasm, however, is tempered by a degree of sadness over the fact that the greatest exploration milestone of my childhood will be revisited only as I'm entering my golden years, sometime in the 2020s. As much as I look forward to watching a new generation of astronauts cavort upon the lunar surface, I'm far more eager to see them rocket off to new horizons, destinations where no astronaut has gone before. I suspect much of the general public would agree.

Mars, of course, is the world we've dreamed of exploring at first hand for decades. As the only place accessible to astronauts that once may have harbored (and may still harbor) some form of life, Mars holds tremendous promise and temptation. But NASA Administrator Michael Griffin recently announced that the first human mission to the Red Planet won't take place before 2037. People who were children during the *Apollo* era will be in their 70s or 80s by then. Time certainly does fly, even when astronauts don't.

YOND

NASA's next-generation launch vehicles are depicted here, blasting off side by side. Ares I (left) will carry Orion, *the crew exploration vehicle, into low Earth orbit.* Orion, *shaped like the* Apollo *capsules but with a roomier interior, can accommodate up to six astronauts. Ares V, the heavy-duty lifter, will deliver large-scale hardware, including the lunar lander, into space.* Illustration: NASA/MSFC

The Moon and Mars, however, are not the only targets in our solar system within reach of *Orion*. A small but growing grassroots movement comprising scientists and engineers at NASA and other organizations is studying potential *Orion* missions to other worlds. Many of these worlds, some of which are referred to as near-Earth objects (NEOs), can be reached more easily than the Moon, and they may be of even greater scientific interest. And there are a number of reasons, beyond science, for dispatching astronauts to these targets—perhaps before the next Moon landing.

A NEO Agenda

Our solar system was born nearly 5 billion years ago from a vast spinning disk of gas and dust that slowly accreted into small, rocky bodies called *planetesimals*. Eventually, through the relentless action of gravity, most of these bodies merged into the planets we know today. Collisions were common in the era of planet formation, and the celestial bumping and grinding was particularly intense in the region between Jupiter and Mars. Instead of a planet, this territory became a planetesimal graveyard. Today, we call it the asteroid belt. It is populated by countless rocky objects ranging in diameter from a few meters to 950 kilometers (590 miles).

On January 1, 1801, Giuseppe Piazzi became the first man to identify an asteroid. He named it Ceres, after the goddess of the harvest. Numerous additional asteroid discoveries soon followed. In more recent years, we've learned that some asteroids orbit much closer to Earth than to Mars. These nosy neighbors are called NEOs.

The idea of a piloted mission to an asteroid goes back to at least 1966, when a Northrop engineer named Eugene Smith proposed using *Apollo* hardware to send two astronauts on a 500-day journey to a NEO named Eros. Eros periodically passes a mere 14 million miles from Earth. Smith argued that a piloted mission there would be a valuable interim step before tackling the much more ambitious goal of a human mission to Mars, and it could be accomplished using the *Apollo*/Saturn V hardware then in development. The flight was planned for 1975, after the first lunar missions had been completed.

Unfortunately, this striking proposal didn't get very far. After the Moon landings, public interest in NASA, as well as funding, began to dry up. Dreams of human forays beyond the Moon died on the budget vine. (The only other purpose to which the mighty Saturn V was ever put was to launch Skylab in 1973.)

In the mid-1980s, Carl Sagan and Louis Friedman discussed the feasibility of piloted asteroid missions in a *Planetary Report* article appropriately titled "Expeditions to the Asteroids." Various mission scenarios were examined, but none of them could be realized with the space shuttle. That constraint soon will change. *Orion*, the Crew Exploration Vehicle that will replace the shuttle, makes NEO missions possible.

A Feasibility Study

NASA recently sponsored a new study of potential NEO missions based on *Orion* and the new Ares launch vehicle that will carry it into space. Scientists and engineers at NASA Johnson Space Center and NASA Ames, assisted by the Jet Propulsion Laboratory (JPL), determined that a NEO mission was indeed feasible and would help NASA "regain crucial operational experience conducting human exploration missions beyond the Earth-Moon system."

Because of their orbits, NEOs are the most readily accessible pieces of real estate in the solar system. The amount of energy required to rendezvous with and return from an Earth crosser is significantly less than the amount of energy necessary to reach and return from the Moon. In fact, a few NEOs are even easier to get to than lunar orbit. An *Orion* NEO mission might not even require the Ares V heavy-lift launch vehicle envisioned for lunar missions (see sidebar on page 8). A separate Ares I launch with an upper stage similar to a Centaur rocket would be sufficient to propel an *Orion* capsule to a NEO encounter. *Orion*'s own service module engine would bring the astronauts home.

A recent NASA study focused on the feasibility of using* Orion *and its new launch vehicle, Ares, to visit near-Earth objects (NEOs) determined that such a mission would give astronauts important operational experience outside Earth's orbit, thus building confidence for future missions beyond the Earth/Moon system.

These imaginary concepts using* Orion *depict a human mission to a NEO. At left, the spacecraft is using an airbag ring and sensors that can detect and transmit details on the safety of the landing site. Once the ground is deemed secure, barbed tethers would then spring out of the craft, anchoring it. Once landed (right), astronauts would emerge from the spacecraft holding onto rope tethers to prevent them from floating to the surface or, worse, out into space. *Illustrations: DigitalSpace*

Depending on the particular asteroid and the distance of its closest approach, two astronauts could complete a NEO mission in as little as 90 days, with a stay of as long as 14 days at the asteroid. (Some of the missions examined in the current NASA study last as long as 180 days.) The crew would travel several million kilometers from Earth, farther than any human being has ever ventured, echoing the daring flight of *Apollo 8*—the first mission to carry astronauts beyond Earth orbit.

The scientific value in studying asteroids is clear. They are the remnants of the original building blocks of our solar system and represent a diverse population of mini-planets. Some are solid and dense and rich in metals, whereas others are little more than floating, shifting piles of rocky rubble. A few robotic missions have given us close-up looks at a smattering of asteroids, but detailed analysis of their composition and structure is essential for full understanding of the early history of planetary evolution. During a two-week encounter, a pair of astronauts could study in unprecedented detail the surface morphology, geology, chemistry, and internal structure and composition of one of these ancient objects.

A human mission could accomplish infinitely more than any conceivable robotic mission. Humans are much more flexible than robots, and they can adapt their exploration strategies in real time. They could easily place instrument packages on an asteroid's surface for long-term measurements, as well as gather and return samples for further laboratory analysis. This rich scientific harvest is the primary justification for a NEO mission, but hardly the only one.

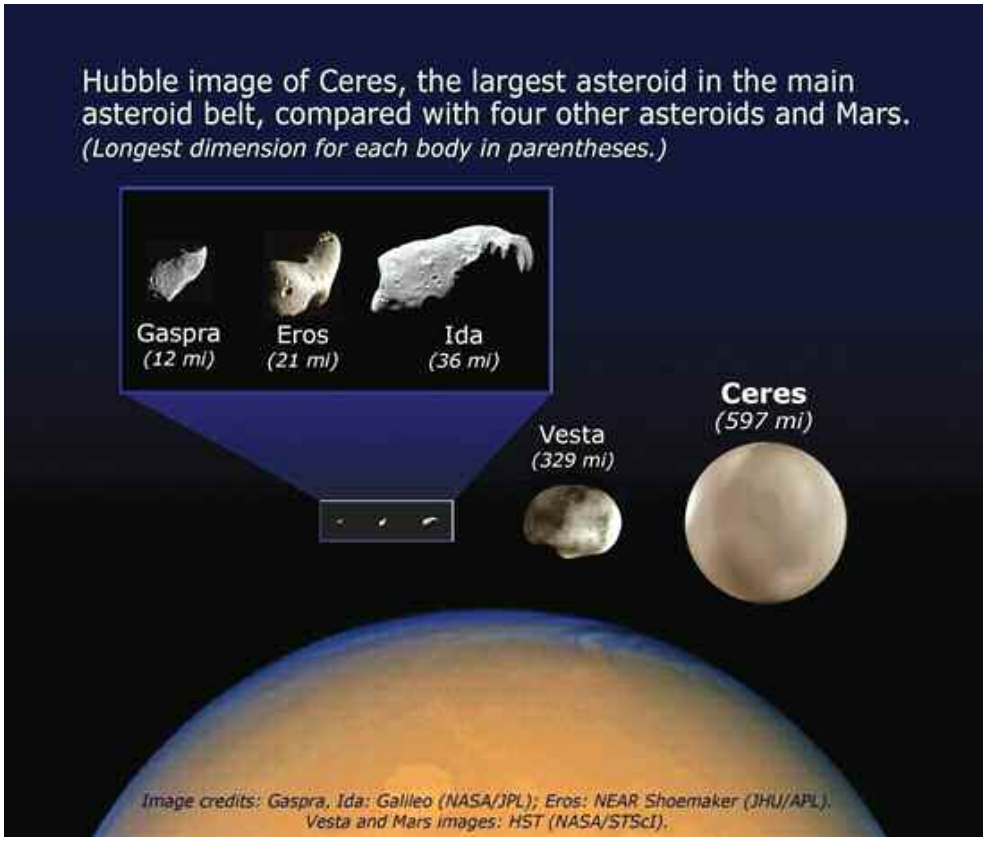
Homeworld Security

There is little question that NEOs pose a potential hazard to the long-term future of life on Earth. It is generally agreed that some, if not all, planet-wide extinction events in our history were caused or accelerated by asteroids blasting our biosphere. Our lives are unquestionably contingent on astronomy and the vagaries of celestial mechanics.

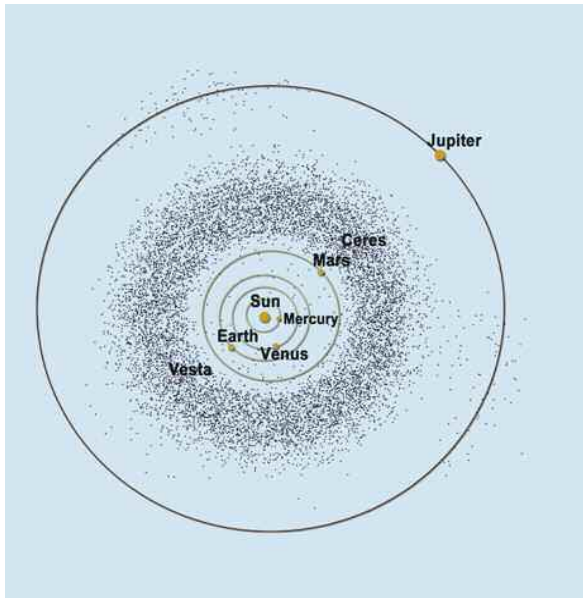
In 2005, Congress directed NASA to identify and characterize all NEOs down to a diameter of 140 meters for the purpose of protecting our planet from a potentially catastrophic impact. The possibility of a doomsday asteroid colliding with Earth in our lifetimes obviously is remote. Something on the scale of the Tunguska event—when an impact of a NEO estimated to be some 100 meters in diameter smashed into Siberia in the early 20th century—could, however, easily happen again in the next few decades. An impact of that magnitude in an unpopulated area probably would not harm a single human being (the asteroid would most likely strike the ocean, with a small chance of raising a tsunami). An unlucky strike in an urban area would cause death and destruction comparable to that of a hydrogen bomb. Wherever it hit, a Tunguska-scale event would certainly draw more attention to the potential threat posed by NEOs and would increase political pressure to seek some way to protect ourselves from them.

Shakedown Cruise

The "valuable interim step" on the road to Mars that Eugene Smith imagined for his asteroid mission 40 years ago still makes sense. NASA today has relatively



Ceres and Vesta, the asteroid belt's largest denizens, are shown here along with three other familiar asteroids, compared with Mars for scale. Ceres is approximately 950 kilometers (590 miles) across, while the average of Vesta's diameter is roughly 530 kilometers (329 miles). NASA's* Dawn *spacecraft will give us a robotic-eye-view of these two worlds when it visits Vesta in 2011 and Ceres in 2015.



Between the orbits of Mars and Jupiter lies the asteroid belt, a ring of rocky rubble left over from the formation of our solar system. These pieces of planetary construction debris range in size from a few meters to about 950 kilometers (590 miles) across. Some of the Earth-crossing asteroids we know today spend part of their time in the asteroid belt.
Illustration: NASA/JPL

little operational experience in long-duration human missions beyond LEO and no experience with astronauts in interplanetary space. Not only will testing *Orion* on a NEO mission reduce the later risk of undertaking missions to Mars, but long-term stays at the lunar poles and the Moon's farside, at other asteroids, and at additional translunar points are also of interest.

A three- to six-month mission to a NEO will expose astronauts to radiation levels exceeding those experienced by International Space Station (ISS) crews. The *Orion* spacecraft will be designed to provide protection against interplanetary radiation, of course, but how well it performs in that regard is something that can be validated only by experience. Beyond the obvious danger for astronauts, electronic equipment also can be adversely affected by ionizing radiation. Data from deep space missions lasting a few months could be extremely useful for better understanding and learning to protect against these risks on longer missions. Such missions would provide more insight into the physiological impact of piloted Mars missions than would a few days on the Moon.

Beyond the physical concerns, there is a psychological dimension to deep space exploration that has never been explored. A NEO mission will carry astronauts several million kilometers from home. At such distances, Earth is reduced in apparent size to about that of a pea held at arm's length. No human being has ever ventured so far from our planet. How will that affect the mental and emotional state of an astronaut? Talking to the folks back home also becomes more complicated. It takes one and a quarter seconds for a radio signal traveling at the speed of light to reach the Moon—a relatively scant 380,000 kilometers (235,000 miles) away. When distances are measured in millions of kilometers, the two-way lag starts to resemble communication by carrier pigeon. Conversations with mission control in real time are no longer feasible.

Nick Kanas, a professor of psychiatry at the University of California, San Francisco, believes that these conditions will pose a "unique stressor" to the human psyche. It is entirely possible that feelings of extreme isolation and loneliness will have significant impacts on crew performance. It may be wise to study and understand these stresses and find ways to ameliorate them before committing astronauts to a Mars mission.

Lunar Politics

It may seem premature to discuss missions to NEOs before *Orion* is even ready to fly to the International Space Station (ISS). Funding for the program will be relatively small until space shuttle crews finish assembling the station, and the specifics of the design are still subject to revision. The vehicle NASA ultimately builds may differ from the current baseline design due to unforeseen technical problems or budget constraints. On the other

CONSTELLATION

The NASA Constellation program will develop and construct a reusable Crew Exploration Vehicle (*Orion*) and two new launch vehicles.

***Orion* will have the shape of *Apollo* but with more than twice the internal volume. It will accommodate a crew of up to six and will be launched into orbit by a two-stage rocket dubbed Ares I. A reusable five-segment solid rocket booster derived from the strap-on boosters that help launch the space shuttle will constitute the first stage. A liquid-fueled second stage will carry *Orion* the rest of the way to low Earth orbit (LEO).**

The real muscle of the Constellation program will be a heavy-lift launcher, Ares V, capable of lofting more than 100 metric tons. Its principal task will be to launch an Earth departure stage and lunar lander into LEO. Riding an Ares I, an *Orion* capsule and service module will rendezvous with the departure stage/lander for missions to the Moon.

ATK is the prime contractor for the solid-rocket Ares I first stage, and Boeing for the liquid-fueled upper stage. Some have questioned the need to develop a new rocket just to launch crews to the International Space Station, arguing that existing Delta 4 and Atlas 5 expendable launch vehicles could be adapted for the job. NASA, however, sees Ares I as an important precursor to an Ares V heavy-lift development program that would be needed for Moon and Mars missions. If a NEO mission is undertaken as an interim step on the road to Mars, the urgency for Ares V would be lessened (although the launch vehicle will still be needed for eventual human missions to Mars).

Lockheed Martin has been selected as the prime contractor for *Orion*. Flight hardware is expected to be ready by the end of 2014. Ares V is not expected to go into service before 2017. —*AB*

hand, the die has been cast, at least in the programmatic sense. The space shuttle will be retired in three years, eventually to be replaced by an *Orion*-style crew vehicle and new rockets to launch it. That system may prove to be NASA's only ticket out of LEO for several decades to come.

Beyond ISS, the only destination the president and Congress currently have in mind is the Moon. John Logsdon, director of the Space Policy Institute at George Washington University and a past member of The Planetary Society Board of Directors, believes that it is perfectly reasonable to ask what else *Orion* can do. He adds, however, that "advocates of alternative missions have their thinking backward in the sense that there's so much emphasis right now on the Moon, and international collaboration on lunar exploration, so much momentum behind that, that the chances of getting approval for other missions is vanishingly small" until the goal of returning to the Moon has been achieved. Trying to gain acceptance for a mission that has not been mandated by the president or Congress before a suitable target asteroid has even been selected strikes Logsdon as a political nonstarter.

Planetary Society Executive Director Louis Friedman believes, however, that "political winds are changing, and the next administration is likely not to be bound by the current emphasis on the Moon." Humans exploring an asteroid, bounding about its surface in near weightlessness and conducting observations related to protecting the Earth, would arouse far more public interest and excitement than a return to the Moon. "This is the point of the article I wrote with Carl Sagan more than two decades ago," Friedman added.

Rob Landis, a coauthor of the most recent NEO mission study, also notes that the original lunar landing goal President Kennedy set in 1961—after only 15 minutes of human spaceflight experience—also aroused a great deal of skepticism. But Kennedy was firmly behind his Moon goal, and he was able to convince Congress to fund it. Whether a grassroots movement can precipitate the adoption of another goal for human space exploration is an open question.

It is also far from certain that humans will even return to the Moon, let alone travel beyond it. The federal budget is under extraordinary pressure. Defense spending currently exceeds $750 billion a year. That figure is likely to grow for the foreseeable future. Coupled with the coming tidal wave of "entitlement spending" for aging baby boomers (on such programs as Social Security and Medicare), the squeeze on discretionary spending will be intense. A new mandate for human exploration of the solar system may be a luxury the next president decides we can't afford.

On the other hand, baby boomer nostalgia for the glory days of *Apollo* may help motivate Congress to spend the dollars necessary to keep *Orion* on track. *Orion*, or something very much like it, is the minimum necessary to keep American astronauts in space. As long as the Russians and Chinese are going there, it seems unlikely we'll decide to stop. The Chinese have announced their intention of sending people to the Moon, and they may well get there before us. Of course, there's no guarantee

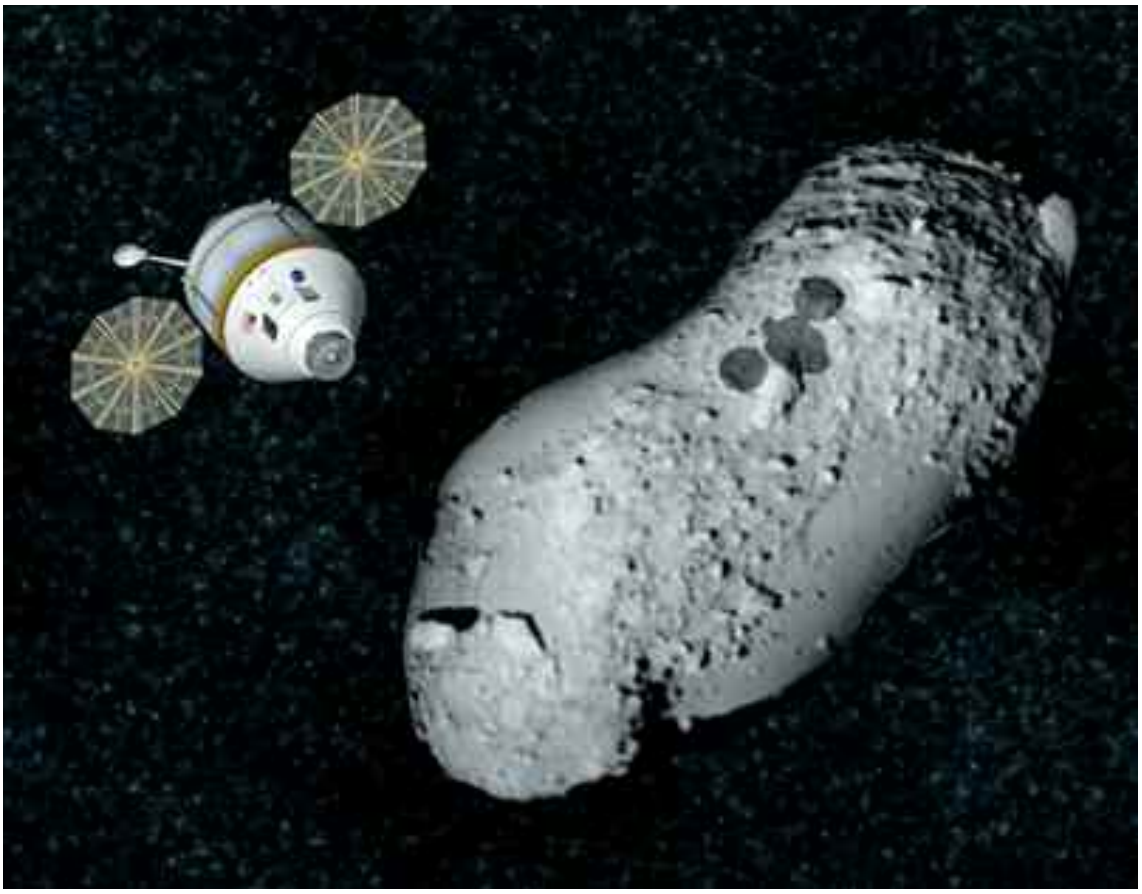
that the Chinese will achieve their goal, or that they will maintain a permanent presence on the Moon if they get there, but such an event would be a powerful incentive for America to reestablish a lunar capability.

It may well be true that, from a technical perspective, NEOs constitute the most readily accessible property in the solar system. Exploration, however, is never a purely technical undertaking, and if it requires the resources of a democratic government, it will not succeed without goals that have enough value in the eyes of the public to garner the necessary political support.

Going back to the Moon after such a long absence is certainly alluring, but maybe it's time for something completely different. We've learned a great deal about the solar system since the days of *Apollo*, including a new appreciation for the uniqueness and value of its smallest denizens. When it comes to winning the attention of the public, novelty is one of the most powerful forces. Russian and American "space firsts" commanded headlines for most of the 1960s. As *Orion* takes shape, we should at the very least remain open to the possibility of using it to conquer new horizons as well as familiar territory.

Andre Bormanis is a television writer and producer. His credits include the 2005 CBS dramatic series Threshold *and the UPN series* Star Trek: Enterprise *and* Star Trek: Voyager. *He holds degrees in physics and science policy and recently helped write the planetarium program "Centered in the Universe" at Los Angeles' Griffith Observatory.*

Mission controllers at Cape Canaveral celebrated one of humanity's greatest achievements the day* Apollo 11 *landed on the Moon. Can our desire to relive the jubilation of seeing the first humans walk on another world help us to convince Congress to keep* Orion *in the budget? If Americans want to see their astronauts in space alongside the Russians and Chinese, the* Orion *spacecraft will be necessary. ***Photo: NASA***



Our knowledge of all the worlds in our planetary system has increased profoundly since the* Apollo *astronauts walked on lunar soil. Although we long to return, perhaps a piloted visit to one of our smaller neighbors—a near-Earth asteroid—will rekindle the unique thrill of exploring a new and unfamiliar place, a world beyond.
Illustration: NASA/JAXA

A Night to Remember: The Planetary Society's

High above Manhattan's skyline, members and friends of The Planetary Society gathered at the New York Academy of Sciences on October 19 for the Society's 2007 Awards Celebration: Planetary Citizenship in the Next Space Age.

"Unlike the Academy Awards, we're only presenting two awards this evening," noted Neil deGrasse Tyson, Planetary Society president and cohost of the evening's festivities. "We're here to have a conversation with you," continued Planetary Society vice president and cohost Bill Nye the Science Guy®, "about what it is to be a Planetary Citizen." His remarks set the stage for a lively evening of debate and good humor.

The Cosmos Award

Neil presented The Cosmos Award for Outstanding Public Presentation of Science to *NOVA* Senior Executive Producer Paula S. Apsell. In accepting the award for what Neil termed "setting the gold standard in TV science documentary," Paula applauded The Planetary Society. "You are an organization that shares *NOVA*'s mission—public understanding of science. You have kept alive the passion for discovery, something that is rare in our society," she told the audience as she admired the hand-blown crystal sculpture of a ringed planet that Neil presented to her.

Paula showed a film clip of some of *NOVA*'s most spectacular shows from the past 30-plus years—among them expositions on air flight, crossing the Antarctic, the Mars rovers, storm watchers, profound scientific illiteracy (as illustrated by Jay Leno's interviews of passersby), mummification, *SpaceShipOne*, ocean exploration, and desert caravans. The clip highlighted the many kinds of science that have shaped our lives.

The beauty and thrill of the images masked the complexity involved in choosing which stories to tell and how to tell them. "Our job at *NOVA* is to entice our viewers into science," not to alienate them, Paula explained as she showed a second clip, from *Judgment Day: Intelligent Design on Trial*, a new *NOVA* documentary coproduced with Paul Allen's Vulcan Productions.

She described the difficulty she and her colleagues faced in deciding whether and how to create this program concerning the Dover, Pennsylvania court case that pitted parents against a school district that had added intelligent design to the biology curriculum. Given the alarming number of people who question evolution, "we decided we needed to take this issue on," Paula said.

The Paine Award

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 Science Systems. Mike is known internationally for his stunning images of the Red Planet. He accepted from Jim a Mars flag that had flown on the space shuttle *Discovery*.

Mike, like Paula, is no stranger to debate. He told the audience, "I'm not very well recognized in my own community. I tend to have rather controversial views. One of them is supporting human exploration."

Jim noted that, to date, we have mapped less than five percent of the surface of Mars. He declared his admiration for Mike's work: "He has personally, and painstakingly, targeted the tiny fraction of Mars where it is most important to look. He has completely revolutionized our view and understanding of Mars."

As Mike displayed some of the images for which he is responsible, he suggested that "seeing is not always believing. . . . Exploration is driven by mystery. We're looking for and finding things we don't understand. I'm going to share with you some mysteries, mysteries that have basically been ignored." Pointing to a central mound in Henry crater, he questioned how vast amounts of material were broken down and removed from the crater. Gesturing to "bedrock wave forms" in Terby crater, he called them evidence that there was once a sea in Hellas basin, evidence that has been overlooked.

Mike noted that future human explorers might answer these and other Mars mysteries. The scientific teams engaged in such endeavors will bring to exploration the same elements, he said, that characterize a successful sports team—speed, agility, dexterity, and intelligence.

Planetary Citizenship

The theme of discovery and critical thinking as crucial to humankind continued throughout the evening. Following the awards presentation, Bill and Neil engaged the audience in a discussion about Planetary Citizenship—the need to educate citizens about science and exploration, how politics and science affect each other, and the need to ensure that wise choices are made to benefit all citizens on our planet.

2007 Awards Celebration

BY ANDREA CARROLL

In the last 50 years, the people of Earth have made mind-boggling progress in exploring space—not just in our own solar system but in the universe outside its borders. What progress, what marvels, will the next half century hold for us? The Planetary Society wants to examine what it means to be a Planetary Citizen in the "next space age." Japan's* Kaguya *spacecraft captured this view of Earthset over the Moon on November 7, 2007. Because this picture was taken over the lunar south pole, Earth appears "upside down," with Australia visible at left of center and Asia at lower right. To see more* Kaguya *images as well as movies of the Moon and Earth, go to http://www.planetary.org/blog/article/00001230/.

"You lose science and engineering, your society begins to crumble. Your streets blow up. Bridges fall," Neil asserted. "To save Earth," Bill proclaimed, we must "do more with less, and it's all going to be science." Citing the famous *Voyager* image of Earth as a pale blue dot, he explained, "Everything you do affects everyone in the world. There's no one coming over the hill to save us." He added, "You only get that perspective when you see Earth from space."

Neil and Bill fielded questions and comments from the audience in a conversation about the possibility of life on Mars and how such a discovery would alter our fundamental understanding and definition of biodiversity. "It's what keeps me awake at night . . . in wonderment," Neil admitted. Bill put it simply: "If we found evidence of life on Mars, it would change the world! It would be the citizens of the planet Earth, not a single individual, who made this discovery."

Members of the audience cited the Cold War as a stimulus for space exploration, and some contrasted that motivation with the international cooperation and nonpartisanship that have become hallmarks of space exploration since that era. "Ask someone if they want to go to Mars," Bill said, "and their answer won't tell you their political leanings." Neil suggested that although "it's audacious to even think that way," this unique mix, along with the potentially powerful societal influence of Planetary Citizens, might one day circumvent what he defined as "civilization's drivers" of huge financial projects: "war, promise of economic return, and praise of things more powerful than you." It would be a "fundamentally different kind of world," he noted; "in a planetary world society, discovery is itself a good reason to explore."

From the presentations and speeches, guests proceeded to a reception of hors d'oeuvres and heated conversation—all in the name of Planetary Citizenship.

Andrea Carroll is director of development of The Planetary Society.

Miles Kwiatek, one of The Planetary Society's younger members, had a great time at the celebration. Here he takes a moment to pose with Society president Neil deGrasse Tyson.

Photo: Hillary Kwiatek

2007—THE Y

The year 2007 certainly has been one of the most active in planetary exploration. Of the 20 robotic spacecraft in operation, 11 returned images to Earth from four planets plus numerous moons, including our own recently neglected natural satellite.

Mars remains, for the present, the main focus of exploration efforts, with five spacecraft devoted to studying it. *Mars Reconnaissance Orbiter* joined *Mars Odyssey* and *Mars Express* in mapping the Red Planet, witnessing from space a dust storm that blocked the surface and threatened the survival of the two rovers, *Spirit* and *Opportunity*. The rovers weathered the storm and in so doing passed the milestone of two complete Mars years of surface operation. All three orbiters have been hard at work preparing for the next Mars landers, performing detailed mapping of possible future landing sites. The European Space Agency's comet chaser *Rosetta* briefly joined the party at Mars, flying by in January, and *Phoenix* launched in August for a 2008 Mars landing.

Looking farther outward, *Cassini* completed nearly 20 orbits of Saturn, most of them swinging th the ring plane. The top-down viev the small moons and also permitt ever views of the globe of Saturn f and to map the north polar lake d year, a special, costly maneuver fl returning bizarre images that like as they answer.

Not to be outdone by Saturn, Ju as *New Horizons* picked up a grav spacecraft effectively accomplishe spectacular data both on a planet and on a moon, Io, in the throes o

No spacecraft is visiting Uranus above Earth spent 2007 watching of its December equinox—and the years—brought Earth briefly to t

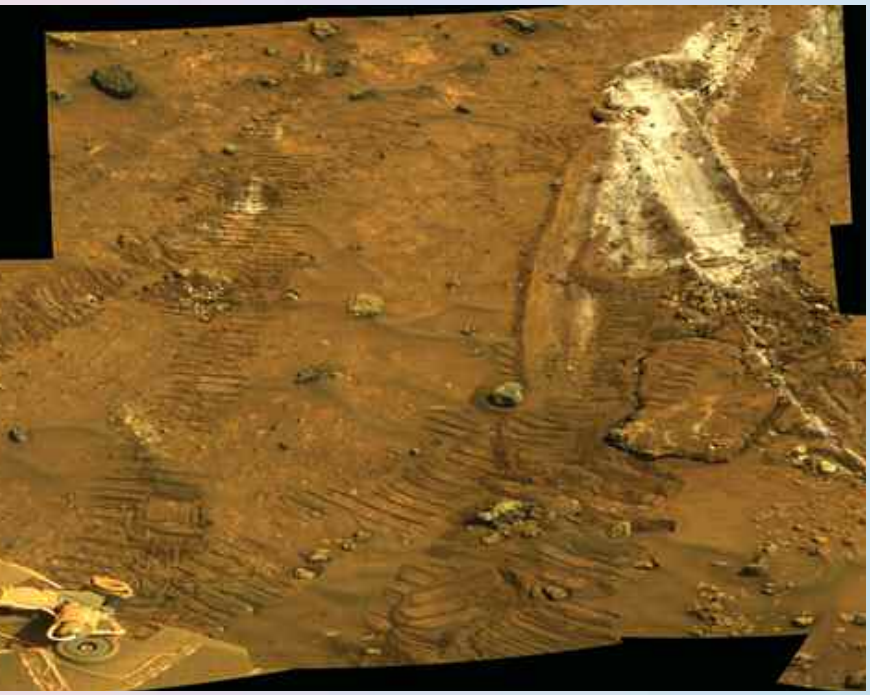


Image: NASA/JPL/Cornell

A DRAGGING WHEEL DIGS UP SILICA

Since driving into the valley below Husband Hill, *Spirit* has been hobbled by a stuck right front wheel. The balky wheel has ended hope for further long drives. The dragging wheel, however, produced a surprising discovery near the feature known as Home Plate. As *Spirit* drove over a patch of ground now called Gertrude Weise, the wheel dug into the soft soil and exposed a patch of a bright white mineral. This is not the first place where *Spirit*'s wheels dug up bright soil, but previous bright soil patches were sulfur-rich. Gertrude Weise was found, upon close examination, to be 90 percent silica.

Amorphous silica is located most often on Earth in association with hot springs or fumaroles (steamy vents found near volcanoes). Water almost certainly was required for it to have formed in such a high concentration on Mars.

McNAUGHT BY McNAUGHT

The arcing, striated dust tail of comet C/2006 (McNaught) blazes across the star-studded Australian sky in a photo captured by the comet's discoverer, Robert McNaught, at the desert location of Siding Spring Observatory. Comet McNaught entered Earth's skies in the Northern Hemisphere, just bright enough to be seen in daylight. Then, for a few days, it was invisible to Earth observers as it passed through its perihelion and a close encounter with the Sun.

The perilous passage ignited a burst of cometary activity: tons of dust and gas erupted from the comet's tiny nucleus and, pushed into slightly more distant orbits by solar radiation pressure, began to trail out behind. As McNaught receded from the Sun, it became visible to Southern Hemisphere observers as the brightest comet seen for 40 years.

Photo: R. H. McNaught, Siding Spring Observatory

EAR IN PICTURES

**e spacecraft far above and below
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floating free within its disk of rings
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he dark side of Uranus' ring plane.**

Closer to home, in 2007, two spacecraft were active at Venus: ESA's *Venus Express* and NASA's *MESSENGER*. (*MESSENGER*'s visit was brief—a gravity swingby to drop it inward toward Mercury.) This year also saw Earth return to the Moon with the launches of Japan's *Kaguya* and China's *Chang'E-1*; these missions inaugurated the International Lunar Decade. The performance of comet McNaught in the southern skies reminded us that sometimes, all you need is your own eyes to appreciate the wondrous beauty of the solar system.

The photos on these pages are just a few of the most dramatic images of the past year; there are too many active space missions to include photos from all of them. As the year comes to a close, we'll includes these and more images from 2007 on our website at *planetary.org/yip*.

***Emily Stewart Lakdawalla is science and technology coordinator for The Planetary Society. She maintains the Society's blog at* planetary.org/blog.**

McNaught's tail was broken up into more than a dozen striations by a process that is still not well understood but probably has to do with discrete episodes of cometary activity causing more dust to be released at some times than at others. Each night, the comet's tail expanded until it occupied nearly 30 degrees of the sky. By the end of February, however, the comet had faded from view, on a return trip to the outer reaches of the solar system, never to return.

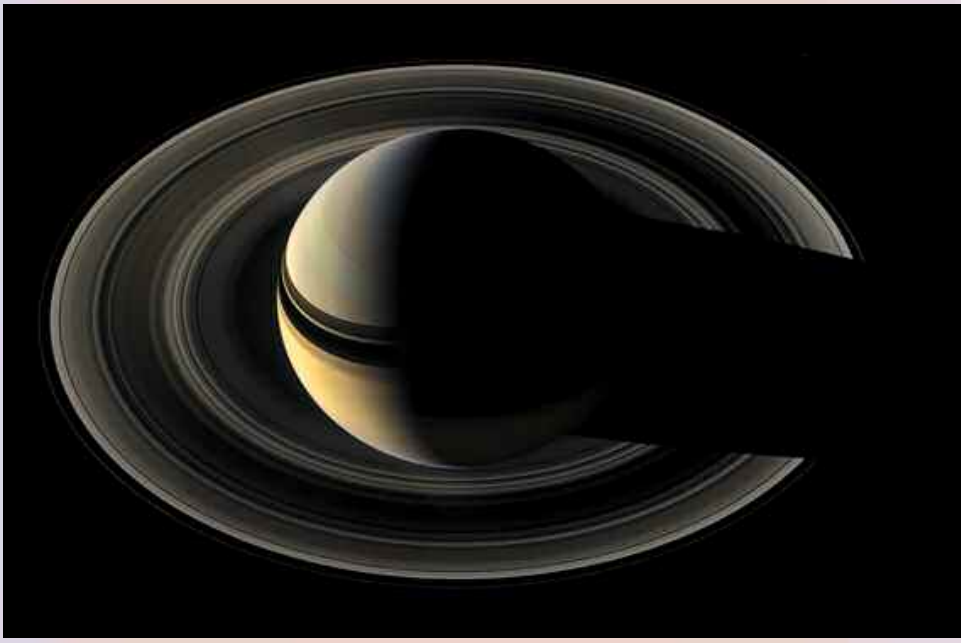


Image: NASA/JPL/Space Science Institute

CASSINI RINGS AROUND SATURN

Saturn's main rings are shown encircling the planet in a view never possible from Earth. *Cassini* has flown to 39 degrees to the north of Saturn's ring plane, gaining a top-down perspective on the rings. From this unique point of view, Saturn's A and B rings (the rings most easily seen from Earth in a small telescope) are visible in their entirety, unobstructed by the planet (although they are darkened by Saturn's shadow). Because it is currently winter in Saturn's northern hemisphere, the rings are lit from behind, so Saturn's most opaque ring—the B ring—appears as a wide, dark band.

It is usually easy to visually distinguish the A and B rings because they are separated by a mostly transparent lane called the *Cassini division*. From Earth, even a small telescope resolves the Cassini division as a black band between the A and B rings. In this image, however, the Cassini division is far from obvious. Unlike the two gaps near the outer edge of the A ring, which appear black in this image, the Cassini division is not entirely devoid of particles. It contains several broad ringlets of fine dust that, when lit from behind, scatter the sunlight forward to *Cassini*'s camera like dust motes in a sunbeam.

This view of Saturn differs from previous views in another way: the shadows cast by Saturn's rings on the planet itself have moved markedly southward since the arrival of *Cassini* at Saturn more than three years ago. That's because winter is drawing to a close in the northern hemisphere; the vernal equinox comes in 2009. The march of the seasons brings changes to almost all the planets, but Saturn's broad ring system makes the arrival of spring even more significant. From equinox to equinox, one entire side of Saturn's rings remains constantly illuminated (except when it passes through Saturn's shadow), while the other side of the rings remains constantly in darkness. The arrival of spring in the northern hemisphere will light up the north side of the rings for the first time in 15 years. *Cassini* should remain functioning through Saturn's equinox and will be capturing images of the rings and the planet to see how they respond to the arrival of the Sun.

NILI FOSSAE TROUGH

The blooming purples and greens in this image of the west wall of Nili Fossae, northwest of Mars' Isidis basin, map the signatures of minerals in the Martian bedrock that scientists hope to sample with a future rover. The image represents the best that two of *Mars Reconnaissance Orbiter*'s instruments—CRISM and HiRISE—have to offer. Together, these instruments are performing detailed mapping of all the potential landing sites for the 2009 *Mars Science Laboratory*. Nili Fossae Trough is just one of half a dozen sites being considered.

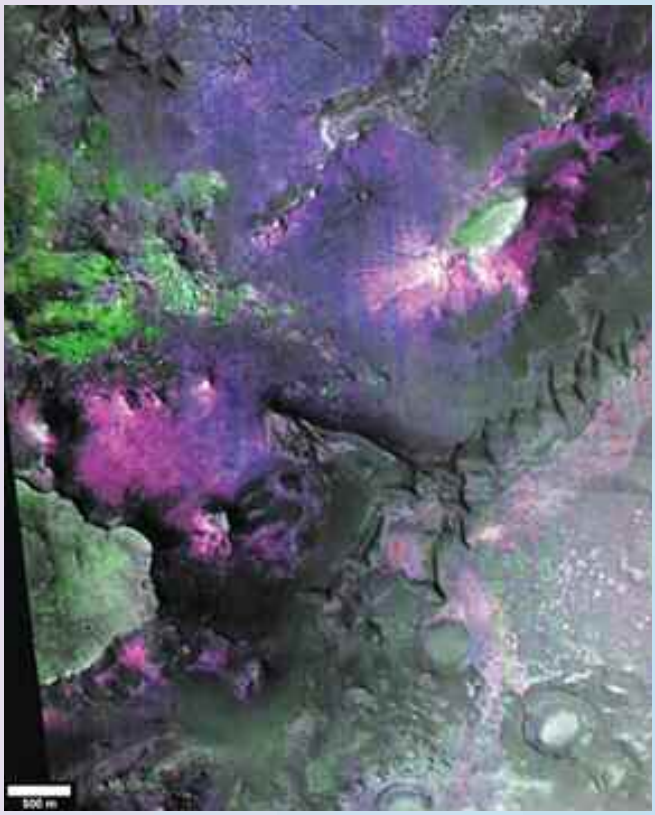


Image: NASA/JPL/University of Arizona/JHUAPL

The HiRISE camera is taking photos of Mars with resolutions as high as 25 centimeters (about 10 inches) per pixel. With such sharp images, planners for future landed missions can name every large rock in their landing site before they even arrive at Mars. This image reveals the floor of Nili Fossae (lower right) paved with volcanic materials; "shark's-tooth" dunes of dark basaltic sand march parallel to the northwest wall of the trough. An ancient flooding event cut into that wall, carving a landscape of mesas and buttes and exposing ancient bedrock.

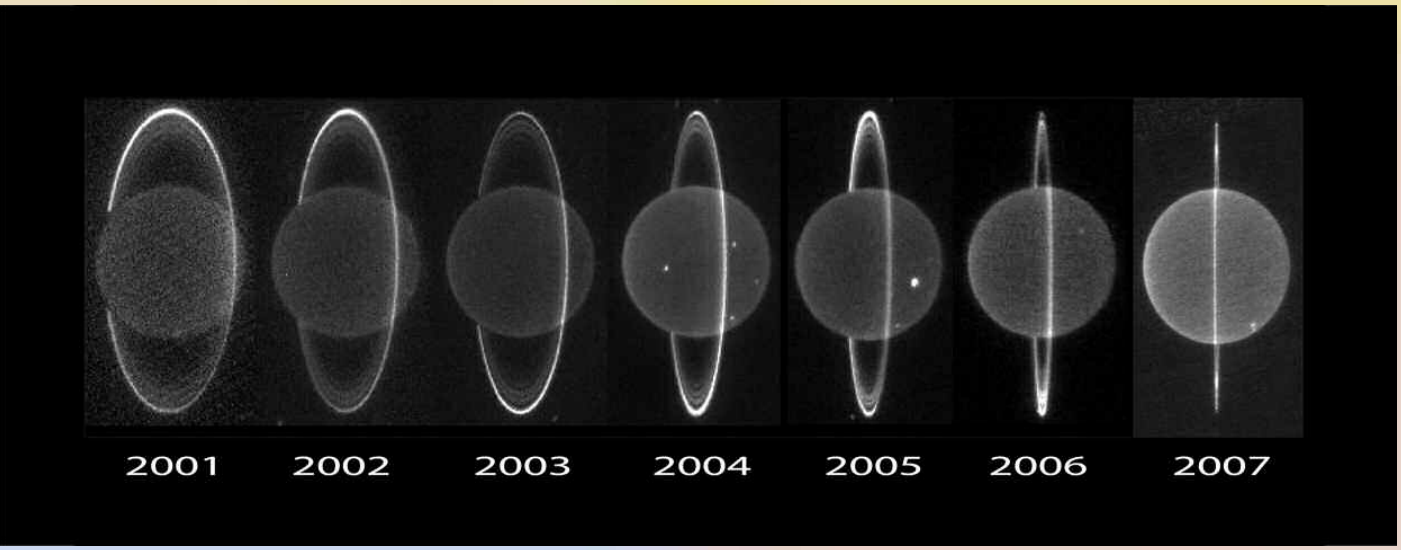
At the same time, the CRISM imaging spectrometer is slicing the colors of Mars into an unprecedented 544 different bands of the electromagnetic spectrum. Because of such high spectral resolution, CRISM workers can search for the fingerprints of specific minerals on the Martian surface. For instance, in this image, the blues and magentas map locations where CRISM sees the spectral signature of phyllosilicates, minerals that form when igneous minerals such as pyroxene are altered in the presence of water. Greenish colors imply the presence of low-calcium pyroxene, a mineral that formed very early in Mars' history with the hottest volcanic activity. A lander sent to one of these greenish areas has the potential to sample Mars' youth.

SPRING AT URANUS' NORTHERN HEMISPHERE

December 7, 2007 marks the first time that Uranus' north pole has seen the Sun in 42 years. When *Voyager 2* visited Uranus in 1986, the planet was near its southern summer solstice. Uranus' famously extreme axial tilt meant that almost the entire southern hemisphere was basking in continuous sunlight. The unchanging solar glare apparently suppressed much atmospheric circulation, making Uranus probably the dullest planet observed by *Voyager*.

As the blue planet's orbit brings it toward equinox, however, Earth-based telescopes have seen bands form and move, and storms flare and dissipate. Many such storms are visible in this time series of images (top of page 15), taken in infrared wavelengths by the adaptive optics (AO)-equipped Keck II telescope on Mauna Kea. The time series also demonstrates the steady improvement of the capability of Keck II AO to resolve fine details of the distant planet's ring system.

Earth crossed the Uranian ring plane from south to north before the equinox, on May 2, affording Earth-based viewers a brief opportunity to see an unusual sight: the unlit side of Uranus' rings. The rightmost image in this series was taken just after this ring plane crossing. The ring that usually appears brightest from Earth—the outer, or epsilon, ring—has virtually disappeared in this dark-side view because the epsilon ring is composed of relatively large particles, and they are hiding each other from view and showing us their shadowed sides. In con-



Images: Imke de Pater (UC Berkeley), Heidi B. Hammel (SSI, Boulder), and the W. M. Keck Observatory

trast, rings composed of dust-sized particles—especially the inner, or zeta, ring—are brighter. The particles in the zeta ring are too sparse to hide each other from view even at this extreme angle, and the tendency of dust to "forward scatter" sunlight makes the zeta ring brighter from this perspective.

On August 16, Earth crossed the ring plane again, back to the sunlit side of the rings. On December 7, the coming of the equinox will mean that Earth is again on the dark side of the rings until the third and final ring plane crossing occurs on February 20, 2008. After that, Earth will not see the dark side of Uranus' rings again for 42 years.

JUPITER'S TURBULENT TERMINATOR

Turbulent clouds whirl at every visible scale in this scan by *New Horizons* across much of Jupiter's disk. *New Horizons* happened to pass by Jupiter during a period of global upheaval—new storms have been appearing, old ones are disappearing or changing shape, and entire bands of Jupiter's atmosphere are changing color.

To prevent *New Horizons*' sensitive optical instruments—designed for much dimmer lighting conditions—from being overwhelmed by the brilliant light at Jupiter's distance from the Sun, this view was taken along the day-night boundary known as the terminator. At the terminator, the Sun illuminates Jupiter's cloud tops almost from the side, so "topography" in Jupiter's clouds creates light and dark shading.

Near the center of this image, in the beige band, there is a subtle fishbone-like vertical striping of mesoscale waves in Jupiter's atmosphere. These waves are somewhat like ocean or earthquake waves: the wave crests and troughs move with a speed that is independent of the motion of the atmosphere. In this case, the atmosphere is moving—that is, the wind is blowing—at a speed of about 100 meters per second (200 miles per hour); the mesoscale waves are moving at 200 meters per second (400 miles per hour).

The image was taken by *New Horizons*' Multispectral Visual Imaging Camera using filters sensitive to blue light and to infrared light at a wavelength of 890 nanometers, where methane—an important component of Jupiter's clouds—strongly absorbs light. Where Jupiter appears reddish, methane is blocking our view into the atmosphere; where the planet appears bluish, the sky is relatively cloud-free, so we are peering through cloud gaps deeper into the atmosphere.

Image: NASA/JHUAPL/SwRI

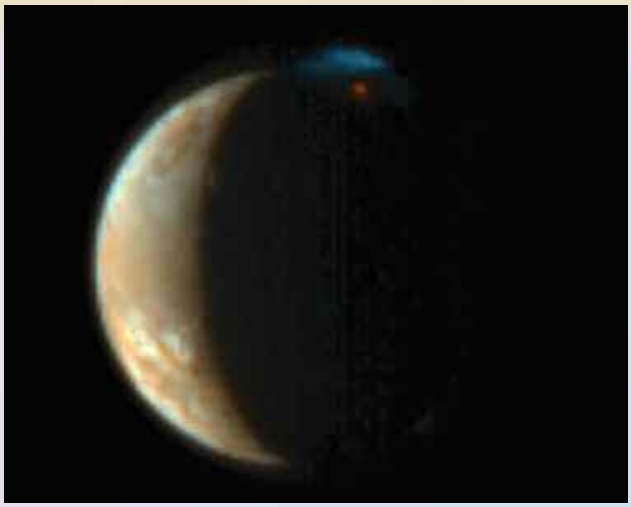


Image: NASA/JHUAPL/SwRI

NEW HORIZONS: FIRE FOUNTAINS OF TVASHTAR

Jupiter's moon Io put on a spectacular fireworks show for *New Horizons* as the Pluto-bound spacecraft picked up a gravity assist from Jupiter in January and February. The primary reason for the Jupiter flyby was to shave time off the long cruise to Pluto, but the *New Horizons* team used the opportunity to conduct a thorough test of systems, instruments, and personnel, packing the flyby with observations from Jupiter, its rings, and its moons.

A few months before *New Horizons*' arrival, Hubble images revealed new volcanic activity near the north pole of Io, and science team members realized that the volcano known as Tvashtar probably was erupting. They were not sure whether the eruption would last until *New Horizons* made it to the system, but Tvashtar didn't disappoint. Because of its north polar location and *New Horizons*' nearly equatorial approach to the Jupiter system, the plume of Tvashtar was silhouetted against the sky in every shot that the spacecraft captured of the violent moon.

This image represents the combined effort of two of *New Horizons*' instruments: the Long Range Reconnaissance Imager (LORRI), which has much lower resolution but no color capability, and the Multispectral Visual Imaging Camera (MVIC), which has much lower resolution than LORRI's but is capable of multicolor images. The approximately true color image was taken just after *New Horizons*' closest approach, so Io is seen in crescent phase.

Tvashtar is erupting on Io's night side. The volcano's incandescent fire fountains, which are a thousand meters tall, are too small to be resolved in this image, but the fiery eruption lights the neck of Tvashtar's plume from within so that it glows red. The hot gas chills as it shoots through space until it condenses into frost, making an umbrella-shaped plume that soars 330 kilometers (205 miles) above the moon. The uppermost reaches of the plume rise above Io's shadow to be lit by sunlight.

On the lower right side of Io's dark limb is another, dimmer plume, actually a pair of plumes from a long eruption and lava flow at Marduk. Marduk is one of many areas where *New Horizons*' images revealed many changes since the moon was imaged by *Voyager* or even *Galileo*.

RETURN TO THE MOON

Japan's *Kaguya* spacecraft has inaugurated a return to the Moon and the start of the International Lunar Decade. *Kaguya*'s instruments include a small onboard camera designed to monitor the physical status of the spacecraft. The photo below of some of the foil-wrapped instruments happened to catch the limb of the Moon in the background. The view is near the Moon's south pole; the largest crater in the view, near the edge of the disk, is Boguslawsky. Also in the background, floating in black space, is a tiny half-full Earth.

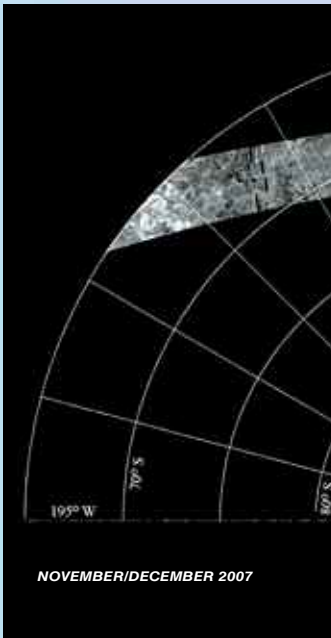
Kaguya is designed to perform a detailed study of the lunar gravity field and is also returning the first high-definition movies from beyond Earth orbit. *Kaguya*'s launch in September was closely followed by that of China's *Chang'E-1* in October. Next year, India plans to join other nations with *Chandrayaan-1*, and the United States plans to launch the *Lunar Reconnaissance Orbiter*.

Image: JAXA

TITAN'S NORTH POLAR SEAS

This year, at long last, *Cassini* found bodies of liquid methane and ethane hiding at Titan's poles. In the decades since methane was detected in the smoggy moon's atmosphere, scientists have suspected the presence of liquid methane on Titan's surface. Any methane in Titan's atmosphere should be destroyed over geologically short periods of a few million years, so its presence means either that we are seeing Titan at an unusual time in its history or that there is a reservoir of methane at and below the surface that replenishes the atmospheric supply.

Cassini arrived at Saturn in 2004 with a suite of a dozen instruments, a few of which could penetrate Titan's clouds in infra-



red or radio wavelengths to see the surface. Throughout the first two years of the mission, no observations were made of areas of possible liquid-filled seas. Finally, during the summer of 2006, *Cassini*'s navigators began to fly the spacecraft above Titan's north pole in maneuvers designed to increase the spacecraft's orbital inclination. This maneuvering had the collateral benefit of allowing *Cassini*'s radar instrument to gather many thin swaths of images near Titan's north pole through a technique known as *synthetic aperture radar* (SAR).

SAR images are in black and white, and the brightness is dependent in large part on the surface roughness and local topography. Surfaces that are rough on centimeter-sized scales, as well as slopes facing the spacecraft, will be bright, whereas surfaces that are very smooth, as well as slopes facing away from the spacecraft, will be dark.

The north polar SAR swaths instantly bore fruit, revealing the darkest surfaces yet seen on Titan, in circular to irregularly shaped depressions, many of which were clearly fed and/or emptied by sinuous, branching channels. Many other similarly shaped features were not quite so dark. Perhaps the darkest features are currently liquid-filled, and the less dark ones are dry. In some areas, dark features grade to a slightly lighter toned shore. Here, it is possible that *Cassini*'s broadcast radio waves are penetrating the shallowest parts of the seas to reflect from a rougher bottom, or even that the near-shore surface of the sea is roughened by Titanian breezes.

Polar passes continued through 2006 and 2007. Up to the time that the image below was assembled in October 2007, the radar team had acquired SAR swaths at a variety of resolutions covering 60 percent of Titan's north polar region above 60 degrees north latitude. About 14 percent of the mapped region is covered by what are interpreted as liquid hydrocarbon lakes numbering more than 400 in various sizes. Most of the lake area is dominated by a few large "seas."

Cassini has now moved on to an orbit that will more frequently cover Titan's south pole and is beginning the search for similar seas there.

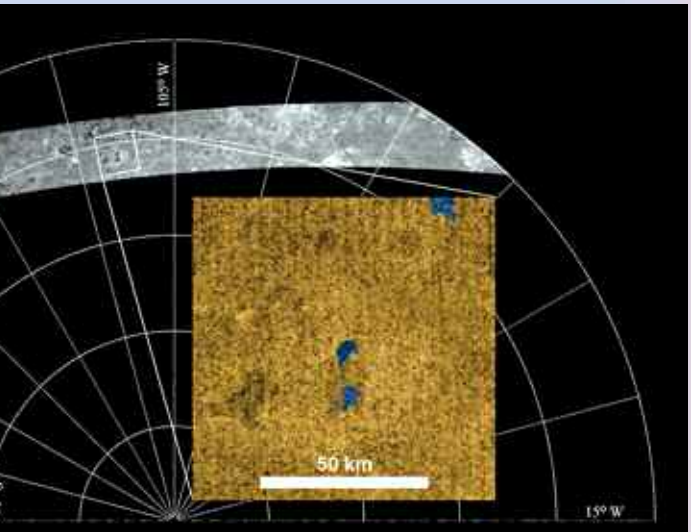


Image: NASA/JPL

Image: ESA/DLR/FU Berlin (G. Neukum)

PHOBOS FROM MARS ORBIT

Mars' three active orbiters typically point down at the surface, peering through the atmosphere to capture photos of rocks, ice, and soil. Sometimes, the view sideways is more compelling, as in this image of Mars' moon Phobos taken by the High Resolution Stereo Camera on *Mars Express* on January 10. Phobos is the inner and larger of Mars' two moons; it travels around Mars' equator once every 7.65 hours. *Mars Express* is in a polar orbit, so the spacecraft and the moon were crossing paths when this photo was taken. Phobos appears crisp and sharp against the blackness of space; below it, the edge of Mars' disk appears fuzzy and striated because of layering in Mars' atmosphere.

The atmosphere on Mars is thin, however, so even when the planet is viewed from this angle, sighting along the longest possible path through the atmosphere, surface features are visible through the haze. You can see a few impact craters below the moon; they appear as line segments that are bright on the left and dark on the right in this severely foreshortened view.

Mars Express has been taking photos of Phobos as opportunities present themselves throughout its four years at Mars, producing enough data to make major improvements to our understanding of the moon's shape, rotation, and orbit. After *Mars Express* fulfills its obligation to listen to critical transmissions during the landing of NASA's *Phoenix* polar lander in May 2008, ESA plans to shift *Mars Express*' orbit to one that will enable it to photograph the area of Phobos on which Russia plans to set down its *Phobos-Grunt* lander, to be launched in 2009.

World Watch

Washington, DC—In a victory for space program supporters, Senator Barbara Mikulski (D-MD) steered passage of her amendment—cosponsored by Senator Kay Bailey Hutchison (R-TX)—through the full U.S. Senate. Most space supporters had given up hope of passage of the extra $1 billion in the amendment for NASA to pay back emergency funding after the loss of space shuttle *Columbia*. The bill passed, however, and now awaits reconciliation with the House of Representatives' version of the NASA appropriations bill.

We thank all Planetary Society members who responded to our call to action in support of the amendment. Your voice made a difference.

The Senate bill, even as amended, does not specifically allocate money to the space science and exploration missions supported by The Planetary Society. The House bill does. We support both bills and are working for a reconciliation that combines the best of both. Keep up on the congressional action at *www.planetary.org/sos*.

To further our involvement in public education and advocacy for space exploration, The Planetary Society has joined with space industry and interest groups in the Coalition for Space Exploration—a group of aerospace companies and space interest organizations that coordinate support for issues affecting the U.S. space program.

Japan and China—Initiating a new era in space exploration, Japan and China launched missions to the Moon: *Kaguya* (formerly known as *SELENE*), from Japan in September, and *Chang'E-1*, from China in October. Both missions took several weeks to reach their final orbits and check out instruments before commencing their science operations.

Kaguya and *Chang'E-1* are both large missions—in fact, Japan's mission is the largest lunar mission since *Apollo*. Both carry ambitious science payloads to study the Moon, and both also represent these nations' significant commitments to future solar system exploration.

Both spacecraft were named after women in folktales: Kaguya, a princess in a Japanese story, and Chang'E, an Earthly woman in a Chinese tale who became immortal and flew to the Moon.

The two missions usher in the International Lunar Decade. India, the United States, and Russia are also developing plans for orbiters; Germany and Italy may as well. Japan, China, India, and Russia plan to follow up with robotic landers. The U.S. focus is on returning humans to the Moon by 2020 as part of the Constellation program.

Los Angeles, CA—While governments around the world prepared to head out into the solar system with their Moon probes, another attempt to stimulate private missions to the Moon was announced. In September, the X PRIZE Foundation and Google Inc. announced a robotic race to the Moon. The winner of the Google Lunar X PRIZE will receive $30 million. The sponsors have challenged private companies from around the world to develop a privately funded robotic rover capable of completing several mission objectives and land that rover on the Moon. More information about the Google Lunar X PRIZE appears at *www.googlelunarxprize.org*.

Moscow, Russia—Is Russia back as a space explorer? Since the launch failure of *Mars '96*, Russia's role in planetary exploration has been limited to cooperation on other nations' missions. One of the most notable of these, the neutron mass spectrometer that is searching for water on Mars, was renewed for the *Mars Science Laboratory* in a recent U.S.-Russian agreement. A similar Russian instrument is also planned for the NASA *Lunar Reconnaissance Orbiter.*

But what about Russian missions? Signs from the Russian space agency, Roskosmos, indicate that the country will again pursue a national agenda of space science and exploration. The *Phobos-Grunt* (soil) sample return mission is being developed for a 2009 launch, with impressive international participation. Piggybacking will be China's first Mars spacecraft to be placed into Martian orbit. Europe will install a radio relay for its 2013 *ExoMars* lander. A small meteorology lander from the Finnish Meteorological Institute and Russia's Space Research Institute may also piggyback on the *Phobos-Grunt* mission, and The Planetary Society's LIFE capsule may be along for the round trip in the first test of transpermia on an interplanetary mission. Some believe that with all these components, plus an ambitious Russian payload, the mission may not be ready for launch until 2011, but preparations continue.

Russia is also planning *Lunar Glob* (globe)—an orbiter with Japanese penetrators set to launch within the next few years—and is studying a follow-up lunar lander around 2012–2014. In the same period, Russia's long-delayed Spectrum-X and Gamma Ray Observatory is also slated for launch, from a new site being developed in cooperation with the European Space Agency in Korou.

There is also talk about future Russian human spaceflight following completion of the International Space Station, including ideas for a new space station and human missions to the Moon and Mars. One Russian space agency spokesperson said that Russia had offered to work with the United States on a lunar base, but I've heard no follow-up.

Roskosmos head Anatoly Perminov described plans for Russian space science at the Russian Academy of Sciences on the 50th anniversary of the launch of *Sputnik*. He spoke of many missions but did not announce a new vision for space exploration. Fueled by petrodollars and with a strong space program infrastructure, Russia certainly has the ability to be a major player in space science and exploration, but does it have the will? The handling of the *Phobos-Grunt* mission will be the first major test of Russia's reemergence into the solar system.

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

Questions and Answers

We frequently hear about the various near-Earth objects (NEOs) that could threaten human lives or our species' very survival. I know we have detected tens of thousands of asteroids with our automated searches. I was just wondering about Mars-crossing asteroids—what are the chances of a relatively large object colliding with Mars in the future?
—Craig Hutchinson
Durham, North Carolina

Our monitoring of the near-Earth asteroid (NEA) catalog for close encounters with all planets—and Earth in particular—is now continuous and automated, but little attention has been given so far to monitoring Mars-crossing asteroids. Even so, about 40 percent of Mars crossers are also NEAs, so they are automatically checked for close approaches to all planets, including Mars. We have found no Mars impacts so far.

Although Mars crossers are about five times as numerous as Earth crossers, Mars is much harder to hit due to its smaller diameter and mass. Moreover, objects orbit more slowly farther from the Sun, further lowering the impact rate. Thus, the rate of impacts on Mars should be roughly comparable to that on Earth. However, Mars' atmosphere will offer much less protection against falling rocks than that of Earth, allowing relatively small asteroids to leave craters on the Red Planet.

For near-term Earth hazards, we focus primarily on those NEAs whose orbits take them within 0.05 astronomical units (AU) of the orbit of Earth—the so-called potentially hazardous asteroids (PHAs). One AU equals 150 million kilometers, or 93 million miles, the distance between Earth and the Sun. The Martian equivalent of these asteroids might be called MHAs, and we've discovered almost 2,000 of them so far, most larger than a half-kilometer in diameter. That's not many, considering that there are perhaps 100,000 (give or take a factor of two) MHAs larger than 140 meters in diameter.

Discovering asteroids at the distance of Mars is more difficult than finding those that pass near Earth. In addition, any Mars impacts in the coming decades are overwhelmingly likely to be caused by the far more numerous smaller objects. Thus, the next Martian impact will almost certainly be from an object too small to be discovered with current telescopes, but we anticipate far more powerful asteroid search programs to become operational in the next five years or so. In particular, the Pan-STARRS (*pan-starrs.ifa.hawaii.edu*) and LSST (*lsst.org*) projects will be able to discover objects smaller than 50 meters at the distance of Mars.

Currently, such objects must approach within about 0.1 AU from Earth to be detected by the ongoing NEA surveys. When the next generation of survey telescopes starts operating, we will likely take the extra step of computing close approach data for all planet-crossing asteroids.
—STEVE CHESLEY,
Jet Propulsion Laboratory

Factinos

Scientists have discovered a fifth planet in orbit around 55 Cancri, a star 41 light-years away in the constellation Cancer. This star now holds the record for the highest number of confirmed planets in a planetary system other than our own.

The newly discovered planet is about 45 times as massive as Earth and may resemble Saturn in composition and appearance. Its location, fourth from its star, puts it in the "habitable zone," a region around a star where the temperature would allow liquid water to collect on solid surfaces.

The research team found the new planet after studying 2,000 nearby stars with telescopes at California's Lick Observatory and Hawaii's W. M. Keck Observatory. For a detailed story on this discovery, go to *http://planetary.org/news/2007/1107_Solar_System_Emerges_around.html.*
—from NASA

Image: ESA

The European Space Agency's *Rosetta* spacecraft snapped a remarkable set of pictures as it completed a critical flyby of Earth and the Moon on November 13 and 14, 2007. The comet-chaser's navigation camera (NAVCAM) took this picture of Earth's limb from a height between 5,500 and 6,250 kilometers (3,400 and 4,000 miles) above the surface. For more, including a terrific view of Earth at night, go to *http://www.planetary.org/blog/article/00001232/.*

We Make It Happen!

by Bruce Betts

Check out Optical SETI—LIVE

You can now check on the progress of The Planetary Society's Optical SETI Telescope on The Planetary Society's website, *planetary.org/special/oseti_telescope/*. Located at Oak Ridge Observatory in Harvard, Massachusetts, ours is the only dedicated optical SETI telescope in the world.

Searching the Sky for Light

Alien civilizations are thought by many to be at least as likely to use visible light signals for communicating as they are to use radio transmissions. Visible light can form tight beams and be very bright, and its high frequencies allow it to carry enormous amounts of information. Using Earth's own current technology, a laser projected through a telescope could be ten thousand times as bright as its parent star, for a brief instant. Such a beam could be observed from vast distances. The sole purpose of The Planetary Society's Optical SETI Telescope is to survey the sky for possible optical light signals from alien civilizations.

In addition to being dedicated to SETI, this telescope is doing the first all-sky survey for optical SETI; that is, the telescope will look everywhere in the Northern Hemisphere, at least briefly, because no one knows exactly where a signal might come from. The telescope scans the sky every night, weather permitting. As of November 2007, it has observed much of the sky once and is now going back over the sky with higher sensitivity.

More Sensitive, but Still Tough

Since the telescope's opening in April 2006, the Harvard team has made it more and more automated to maximize the observing time. Under the direction of Harvard University physicist Paul Horowitz, the team has installed a skycam (also on our website) to complement the telescope's weather station in order to provide information about current weather and sky conditions.

In another big step for the telescope this year, the Harvard team replaced the pixel amplifiers in the system with ones that are five times as sensitive. Once again, Planetary Society funding made this upgrade possible. The change means that the telescope can detect signals that are only one fifth as bright (detecting 20 photons per square meter versus 100 before), which enables the team to observe a much larger set of stars. A weak or distant alien signal that might have been overlooked with the old amplifiers can now come through bright and clear.

What's Up?

In the Sky—December and January

The Geminid meteor shower, the best on average each year with perhaps 60 meteors per hour from a dark site, peaks on December 14. Comet Holmes has been visible (with the naked eye or binoculars) as a fuzzy ball most of the night in the Northern Hemisphere in the constellation Perseus. Its brightness over time is hard to predict, so check online resources for brightness and finder charts. Mars reaches opposition (opposite side of the Sun from Earth) on December 24, rising as a bright reddish starlike object in the east at sunset and setting in the west near dawn. The full Moon appears very close to Mars on the evening of December 23. Extremely bright Venus is in the east in the predawn sky, and Saturn appears to climb higher and higher above Venus throughout December and January. By late January, Saturn will be rising by midevening in the east. Jupiter will appear low in the predawn east in January and will look very close to Venus on February 1.

Random Space Fact

A Martian year lasts 687 Earth days. The two Mars Exploration Rovers have now spent more than two Mars years exploring the planet's surface.

Trivia Contest

Our July/August contest winner is Nancy A. Klauer of Bellevue, Iowa. Congratulations!

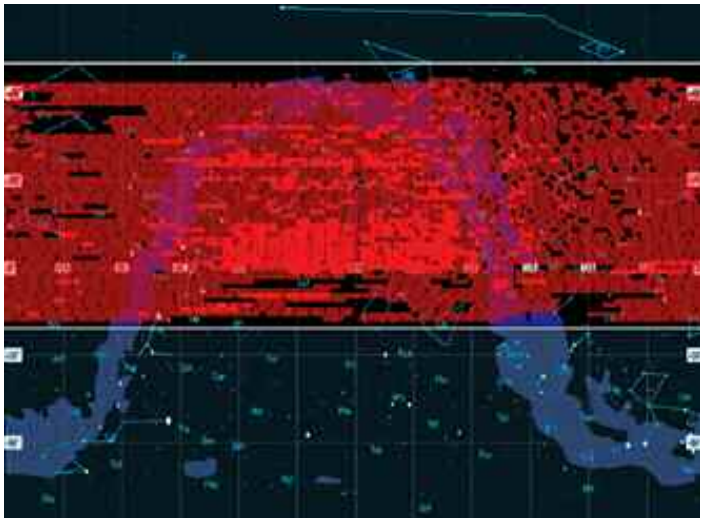
The Question was: What was the second spacecraft to fly by Jupiter? *The Answer*: *Pioneer 11*.

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

NASA's* Dawn *spacecraft launched September 27, 2007. What two asteroids is it scheduled to visit and orbit?

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 February 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.*



Sky coverage of The Planetary Society Optical SETI Telescope as of November 2007. The darker red stripes indicate areas that have been observed once, and brighter red stripes designate areas that have been observed more than once. Most of these regions were observed initially at a lower sensitivity and more recently at a higher one. The dark bands at the top and bottom are declinations that cannot be viewed by the telescope. The Milky Way is shown in blue.

This sensitivity improvement adds to an already staggering set of "gee-whiz" facts about the telescope system. For instance, not only are the telescope's custom electronics able to process the equivalent of all books in print every second, but now, as the telescope scans strips of sky, it uses a custom-built camera containing an array of detectors that can detect a flash of light lasting just a billionth of a second.

Horowitz recently said, "The Harvard SETI group is most grateful to The Planetary Society for a quarter century's loyal support. With a lot of luck, this new search might just catch The Big One!"

What's on the New Web Page?

We have a number of new features at *planetary.org/special/oseti_telescope/*. The new page includes

- A skycam view through the observatory's roof showing the night sky during observations. While the telescope is observing, the page updates every 10 minutes. If the telescope is not in use, the page displays the last image taken before observations ceased.
- A graphic of the telescope showing if it is currently observing and, if active, where it is pointing.
- A map of the night sky as seen from Oak Ridge Observatory showing which regions of the sky have been observed. This map is updated weekly.
- Current data about the telescope's status, updated every 10 minutes.

So check out live information on the telescope you helped make happen. While you are there, you can also follow links to learn more about this amazing tool in the quest to answer the question "Are we alone?"

Bruce Betts is director of projects for The Planetary Society.

Members' Dialogue

A Greater Vision

Dr. Friedman's comments were exactly right [see "World Watch" in our May/June 2007 issue], but without a vision by either the president or by NASA's chief greater than cutting the budget, subsidizing expensive PowerPoint presentations, and leaving the real work to later generations, they mean nothing.

I believe space exploration has been stolen from my generation. We landed on the Moon before I entered 10th grade. I am now 54 and am told it will be 2020 before we go back. The International Space Station is in low Earth orbit (as high as John Glenn went) and it holds three people (the same as Skylab did in the early 1970s). Even advanced probes like the Jupiter Icy Moons Orbiter, with a distant launch date of 2015, have been canceled.

Sometimes the existence of The Planetary Society is the only thing that saves me from complete despair.
—ED GRIFFITH,
Smyrna, Georgia

Research We Can Do

The Vision for Space Exploration will take decades and, in the end, cost us trillions and trillions of dollars that could have been spent far more effectively on robots. It probably will be abandoned for some new "vision" after wasting huge sums. If it does work, we'll still have no real reason to send people into space and no technology to keep them there at costs that are tolerable.

Human space travel is a dead end unless real breakthroughs are made. Until then, we should stick with research that we can do, like focusing on robotics to do real science and do it well. We should keep a small, near-Earth manned effort going just to keep a toe in the water and spend real money developing cheap access to near-Earth orbit—real solutions as opposed to the economic debacle that is the space shuttle. We need to work on telepresence technology so that humans can contribute intelligence to robotic exploration from orbit without actually having to land on other worlds. And we should work on ways to build large structures in space cheaply without dragging every ounce up from Earth.

These are challenges that could keep a space program going for a long, long time and might actually yield something worthwhile.
—ROGER STORY,
Bridgewater, New Jersey

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*

Society News

Announcing Two New Board Members

The Planetary Society welcomes two new members to its Board of Directors: G. Scott Hubbard, a professor in the Department of Aeronautics and Astronautics at Stanford University, and Lon Levin, chief strategic officer of Transformational Space Corporation (t/Space) and senior adviser to Slacker.

Scott and Lon together will bring to The Planetary Society decades of technological experience, business acumen, innovation, and unbridled enthusiasm for the science and adventure of space exploration.

Scott Hubbard worked for NASA for 20 years and was the director of NASA's Ames Research Center from 2002 to 2006. He also holds the Carl Sagan Chair for the Study of Life in the Universe at the SETI Institute. Scott served as NASA's first Mars program director ("Mars Czar") and was lauded for successfully restructuring the Mars program in the wake of several mission failures. He conceived the *Mars Pathfinder* mission, managed the *Lunar Prospector* mission, and founded NASA's Astrobiology Institute. For his distinguished career and many contributions, NASA awarded Scott seven medals, including the agency's highest honor, the Distinguished Service Medal.

Lon Levin, cofounder of XM Satellite Radio, has 20 years of experience in the space, new media, and telecommunications industries. In addition to his work at t/Space, Lon is a senior adviser to Slacker, a company that will offer personal radio via the Web, wi-fi, and satellite. t/Space plans to provide crew and cargo transportation services to low Earth orbit. Lon serves on the Executive Committee of the Space Foundation and the Board of Governors of the National Space Society. He was a founding board member of the Satellite Industry Association and served as its cochair from 1996 to 1998.

Scott and Lon join board members Dan Geraci, Neil deGrasse Tyson, Bill Nye, James Bell, Heidi Hammel, Wesley T. Huntress Jr., Christopher P. McKay, Bruce Murray, Elon Musk, Joseph Ryan, Steven Spielberg, George Yancopoulos, and myself.

—Louis D. Friedman, Executive Director

Galaxy Garden Opens in Hawaii

In October, Paleaku Astronomy Center opened the first-ever walk-through model of the Milky Way galaxy mapped in living plants and flowers, called The Galaxy Garden.

One hundred feet in diameter, the outdoor scale model was designed by Planetary Society adviser Jon Lomberg and is located at the Paleaku Astronomy Center at Paleaku Peace Gardens Sanctuary in Kona, Hawaii.

Jon, who specializes in designing and executing visual presentations concerning astronomy in all media, conceived and designed the garden to encourage scientific education about our place in the universe. Jon worked frequently with Carl Sagan, illustrating several of his books and magazine articles, and was chief artist for the television series *Cosmos*.

Paleaku is a nine-acre nonprofit botanical garden that offers educational and cultural programs, including a monthly Family Astronomy Night. Admission is free.

Visit *www.galaxygarden.net* to learn more about The Galaxy Garden project.

—Susan Lendroth, Manager of Events and Communications

Your Gift Makes a Difference

Within weeks of the 50th anniversary of *Sputnik 1*, the world has celebrated China's first lunar mission, *Chang'E-1*, we've cheered Japan's *Kaguya* orbiting the Moon, The Planetary Society announced the official launch of the International Lunar Decade, and we're heading to Mars with the *Phoenix* lander.

Thank you, members and donors! Your support of The Planetary Society makes a difference. You help craft the projects and advocacy that define the Society, and that, in turn, will shape the future of this next space age.

Are you considering a year-end gift? You can help The Planetary Society in many ways:

- Your gift of cash—by credit card or check—can be made securely online on our website at *planetary.org* or by mailing your gift to Planetary Society headquarters.
- Have a special interest in one of our projects? Support the project or program that excites you most. Again, you can donate securely online or by mail.
- You might consider donating your appreciated stock to help fuel our mission and, in many cases, also avoid capital gains tax on the appreciation in value.

(Because electronic transfers of stock are made without identifying the donor, please let me, or my colleague Lu Coffing, know in advance about the stock and number of shares you would like to donate to the Society.)

No matter the size, your gift makes a difference. Together, let's shape the next space age!

Do you have questions about making a gift? Please call me at (626) 793-5100, extension 214, or e-mail me at *andrea.carroll@planetary.org*.

Thank you, and best wishes from all of us at The Planetary Society.

—Andrea Carroll, Director of Development

May 25, 2008:
Phoenix *lands*
on Mars!
Save the Date!

Planetfest 2008

EXPLORE THE COSMOS!

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.

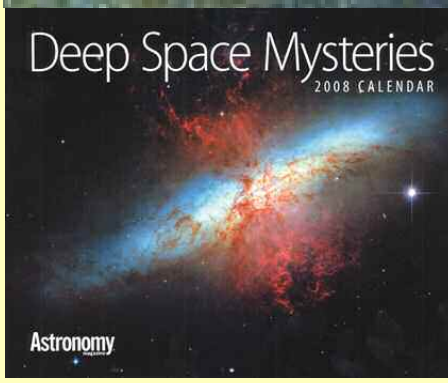
Our Mars replica key fob is emblazoned with the words "I'm Going Here!" with an arrow pointing to the Martian north pole. Don't miss your chance to get this commemorative Mars marble key fob, which features:

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

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

Nebula Poster

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



Deep Space Mysteries: 2008 Wall Calendar

Each month, enjoy magnificent full-color images from deep space. This 2008 wall calendar is produced by the creators of *Astronomy* magazine.
2 lbs. **#520**
Regular price: $12.50
Member price: $11.25

Surf Titan T-Shirt

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

An Explorer's Guide to Mars Poster

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

"Is Anybody Out There?" Poster

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

Pale Blue Dot Poster

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

Mars in 3-D Poster

Red/blue glasses included. 12" x 39" 1 lb. **#306**
Regular price: $15.00 **Member price: $13.50**

Set Sail for the Stars! Poster

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

Pathfinder Images of Mars

20 slides. 1 lb. **#215**
Regular price: $8.33 **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**
Regular price: $15.00 **Member price: $13.50**

SETI@home Mug

2 lbs. **#550**
Regular price: $11.11 **Member price: $10.00**

We're Saving Space for You! Bumper sticker

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

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Planetary Society Lapel Pin

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Planetary Society Cap

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The quest to find life on worlds other than Earth lies at the foundation of our exploration of the cosmos, and the most logical place to look for extraterrestrial life is in places with liquid water. *Distant Sea* depicts what Carol Kucera imagines to be bioluminescent life forms in Europa's interior ocean. Observations of this Jovian moon suggest it has the fundamental ingredients necessary for life: water, organic molecules, a chemical energy source, and a stable environment. Only a spacecraft dedicated to penetrating Europa's icy shell can tell us what—if anything—lives inside that distant sea.

Carol Kucera lives and works in Santa Fe, New Mexico. In 1983, she was commissioned by NASA to paint the launch of STS-7, the space shuttle that carried Sally Ride into orbit. Carol has also produced special commissions for the National Endowment for the Arts and for MCI Communications. This painting is from the collection of David and Jennifer Syndergaard.

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