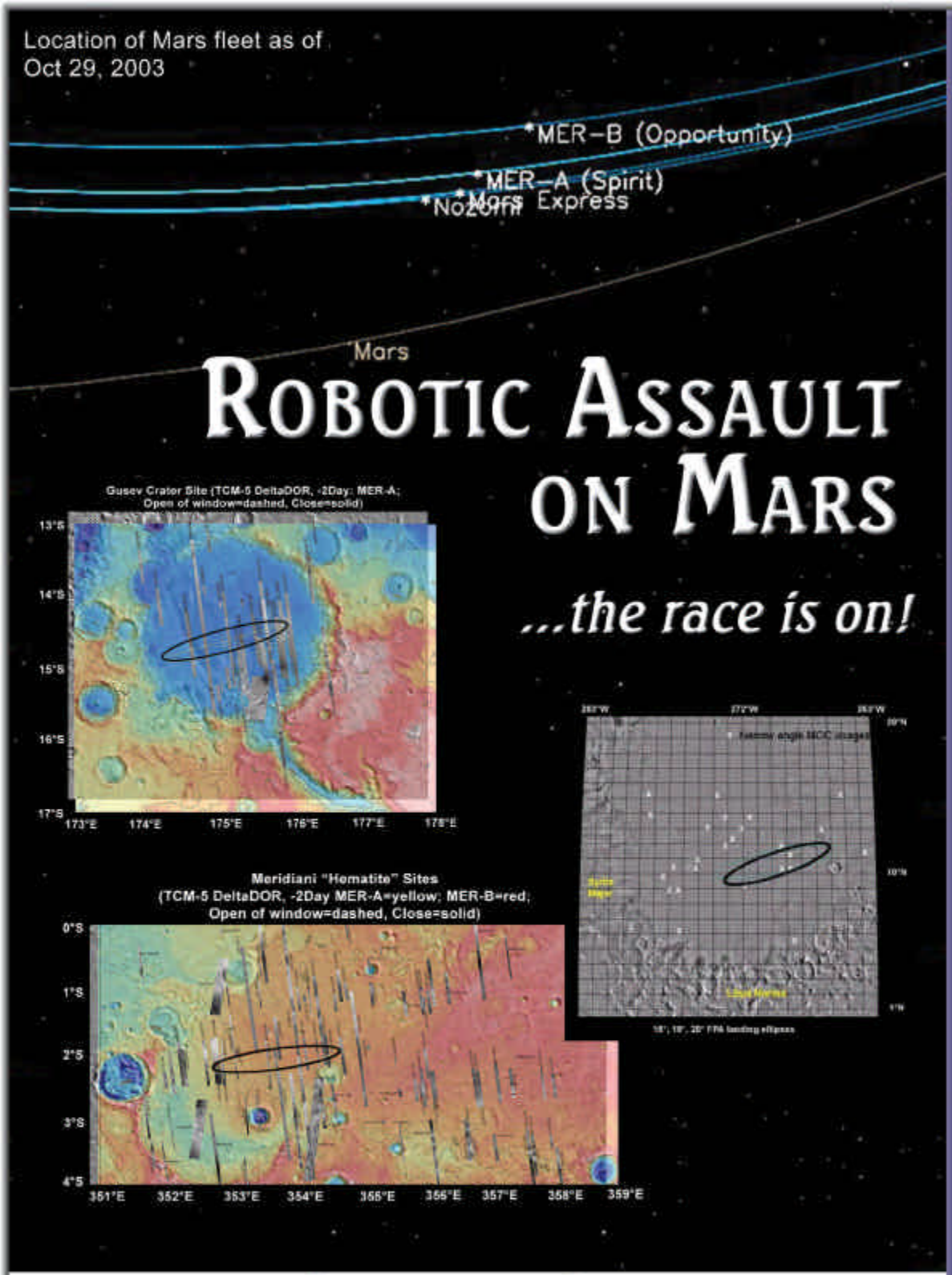

ROBOTIC ASSAULT ON MARS

...the race is on!

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BULLETIN

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Robotic Assault on Mars

— John Connolly,
NASA/JSC Advanced Development Office

Mars is about to be invaded by a small armada of spacecraft. Japan, Europe, and the United States have missions racing to the Red Planet, flying in a millions-of-miles-long formation along an interplanetary arc connecting Earth's orbit to Mars. Though Sir Issac Newton has already determined which mission will arrive first, the clear "winner" is science.

Each of the robotic missions currently on their way to Mars target different scientific areas. NASA's twin Mars Exploration Rovers (MER-A, MER-B), named "Spirit" and "Opportunity," are mobile field geologists that will explore and analyze a wide range of rocks and soils that hold clues to past water activity on Mars. The European Space Agency's Mars Express orbiter, along with the British Beagle 2 lander, will help answer fundamental questions about the geology, atmosphere, surface environment, history of water, and potential for life on Mars. Japan's Nozomi will attempt to perform its martian aeronomy mission.

Why Mars, Why Now?

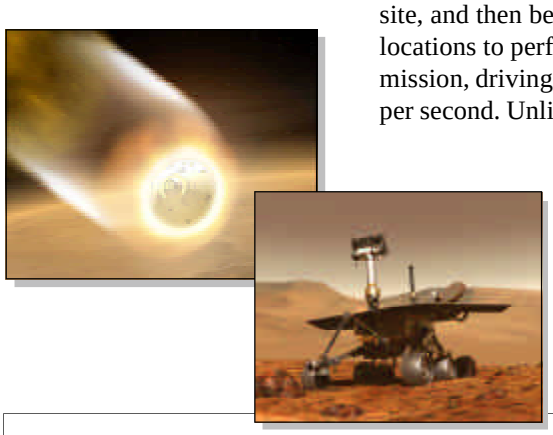
A favorable planetary alignment, highlighted by August's "close approach," gave mission planners a unique opportunity to launch missions to Mars with minimal amounts of energy. In the world of planetary mission design, energy saved translates directly to more payload or smaller launch vehicles, and all the Mars-bound spacecraft took advantage of this low-energy opportunity in one way or another.

At the same time that the propulsive energy required was low, the scientific opportunities were surging. The Mars science community's catalog of science studies is contained in the publication of the Mars Exploration Program Analysis Group (MEPAG). The "MEPAG Document," as it is known, is an excellent scorecard by which to chart the progress of scientific understanding of Mars. Its four distinct scientific goals — life, climate, geology, and preparation for human exploration — are each divided into prioritized objectives, investigations, and detailed measurements. These four main MEPAG goals align closely with a long-standing NASA science strategy for Mars that features water as a theme that cuts across four elements: to understand the potential for life elsewhere in the universe, to understand the relationship to Earth's climate change processes, to understand the solid planet and how it evolved, and to develop the knowledge and technology necessary for eventual human exploration. The missions enroute to Mars promise to answer a significant number of MEPAG's science questions.

Mars Exploration Rovers

The success of 1997's Mars Pathfinder landing and Sojourner rover mission paved the way for the twin rovers launched earlier this year. Both "Spirit", launched June 10, and "Opportunity", launched July 7, will descend to, land on, and explore Mars with systems that have their heritage in the Pathfinder mission. Each of the rovers will be targeted to a different high-priority landing site, with the goal of exploring and analyzing a wide range of rocks and soils that hold clues to past water activity on Mars.

Following a ballistic entry, parachute deceleration and an airbag-protected landing, each craft will settle onto the surface and open, exposing the rovers. After deploying their solar arrays and science instruments, the rovers will take panoramic images of the landing site, and then begin their science traverses. The rovers will investigate promising geological locations to perform onsite scientific investigations over the course of their primary 90-day mission, driving up to 40 meters (131 feet) per day at an average speed of 1 centimeter (0.4 inches) per second. Unlike the Pathfinder mission, neither "Spirit" nor "Opportunity" will be seen from a remote point of view roaming among the martian geology — the only cameras onboard the MER missions will be located on the rovers themselves, but these cameras will transmit stereo imagery taken at human eye-level, giving us all the opportunity to experience the sights as if standing on Mars. Currently, MER-A "Spirit" is scheduled to touch down in Gusev Crater on January 4, 2004, followed by the landing of MER-B "Opportunity" on Meridiani Planum on January 25.



Artist renditions of the MER spacecraft entering the martian atmosphere and the MER rover on the martian surface.

"Spirit" and "Opportunity" carry the same suite of scientific instruments to these two very different landing sites. A panoramic camera (Pancam) will perform the primary imagery function, allowing scientists to identify rock and soil targets and then command the vehicle to traverse to these sites. Once at the location, geological targets can be evaluated by a microscopic imager (MI) that will obtain close-up, high-resolution images of rocks and soils at microscopic scales. Rocks and soils will be analyzed with four other instruments on each rover, and a special tool called the "RAT," or rock abrasion tool, will be used to expose fresh rock surfaces for study.

Robotic Assault on Mars (continued)

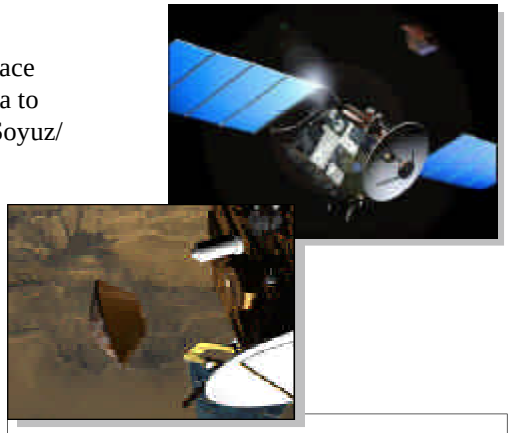
Like a mobile robotic geologist, the rovers will rumble to each new site with instruments at the ready. A miniature thermal emission spectrometer (Mini-TES) will identify the processes that formed martian rocks, and a Mössbauer spectrometer (MB) will identify iron-bearing rocks and soils. An alpha particle X-ray spectrometer (APXS) will perform elemental analysis of rocks and soils, and magnets will be used for collecting magnetic dust particles.

Rover operations will last for at least 90 martian days, extending to late April 2004, but could continue longer if the martian climate and health of the vehicles cooperate. The southern equatorial landing sites for each mission will have an influence over the mission lifetime, as power for the rovers will become scarce as southern hemisphere winter approaches.

The "Spirit" and "Opportunity" landing sites were selected on the basis of intensive study of orbital data collected by the Mars Global Surveyor and Mars Pathfinder missions. Both sites show evidence of ancient water. Gusev Crater (14.59°S, 175.30°E), a wide basin that may once have held a lake, is the destination for "Spirit". The destination for "Opportunity", Terra Meridiani (1.98°S, 354.06°E), is an area about halfway around Mars from Gusev that has a broad outcropping of a mineral — gray hematite — that usually forms in the presence of liquid water.

Mars Express/Beagle 2

The martian science community will receive a holiday gift this year, as the European Space Agency's Mars Express spacecraft and its Beagle 2 lander become the first of the flotilla to arrive on December 25. Europe's first-ever Mars mission was taken aloft by a Russian Soyuz/Fregat launcher in June 2003. The spacecraft is reflying some of the European instruments lost on the Russian Mars '96 mission, as well as a communications relay to support lander missions. Beagle 2, named after the ship in which Charles Darwin set sail, will perform exobiology and geochemistry research.



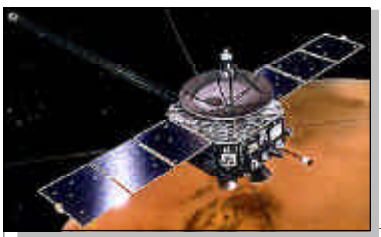
Artist renditions of the Mars Express spacecraft and Beagle Lander making their way to Mars.

The mission's main science objectives are to search for subsurface water from orbit, perform global high-resolution photogeology and mineralogical mapping, analyze atmospheric composition and circulation, and deliver the Beagle 2 lander to the martian surface. Instruments onboard the orbiting spacecraft will study the martian atmosphere, geology, and planetary structure. Orbiter science instruments include an energetic neutral atoms analyzer (ASPERA), high-/super-resolution stereo camera (HRSC), visible and infrared mineralogical mapping spectrometer (OMEGA), radio science experiment (MaRS), subsurface sounding radar/altimeter (MARSIS), infrared mineralogical mapping spectrometer, a planetary Fourier spectrometer (PFS), and an ultraviolet and infrared atmospheric spectrometer (SPICAM).

Beagle 2 is a pocket-watch-shaped lander that will use a simplified airbag system to bounce to a stop after being released from the Mars Express Orbiter. Thirty kilograms (66 pounds) of Beagle's 65-kilogram (143-pound) landed mass is dedicated to science, including a mass spectrometer contained in a gas analysis package (GAP), three cameras, a sample-collecting "mole," a Mössbauer spectrometer, an X-ray detector, and a suite of environmental sensors. Beagle 2 is targeted to the ancient impact basin Isidis Planitia (11.60°N, 269.50°W), where it will conduct a 180-sol primary science mission.

Nozomi

Japan's Nozomi mission was launched in July 1998, and due to a series of malfunctions, has had to use an ingenious series of lunar- and Earth-gravity assists to finally slingshot it toward its January encounter with Mars. Nozomi's primary objective is to study martian aeronomy, with emphasis on the interaction of the martian upper atmosphere with the solar wind. Its 14 instruments are designed to measure the composition of the upper atmosphere, the altitude profile of electron density and temperature, magnetic fields, thermal ion drift velocity, solar wind, plasma waves, and energetic ions and electrons. Other investigations are targeted to measure interplanetary dust and the martian dust ring, radio frequency reflectivity, the deuterium to hydrogen ratio of the upper atmosphere, and the atmospheric helium content, as well as to collect imagery of Mars and its moons.



Artist rendition of the Japanese spacecraft, Nozomi.

Nozomi flew within about 11,000 kilometers (6835 miles) of Earth on June 19, 2003, for a final gravity assist to Mars. The spacecraft's heating system is still not operational because of damage to the power supply by solar flares in 2002, and there is danger of its fuel refreezing before it fires its engines to capture into Mars orbit. If the spacecraft successfully attains orbit in early January, engineers will face the additional challenge of coaxing its damaged solar arrays to produce the energy required to run its science instruments. Like the Japanese word for which this mission is named, engineers are not yet willing to give up hope.

WHAT COMES NEXT?

As if the current multibarrel assault on Mars were not enough, NASA and others have plans to continue the barrage each 26 months when launch opportunities open. Missions are either in development or in design for the 2005, 2007, and 2009 launch opportunities. NASA's Mars Reconnaissance Orbiter (MRO), scheduled for launch in 2005, is envisioned as the next-step-up-in resolution follow-on to the successful Mars Global Surveyor mission. MRO will be equipped with the most powerful camera ever flown on a planetary exploration mission for submeter close-up photography of the martian surface, and will carry a sounder to find subsurface water and look for safe and scientifically worthy landing sites for future exploration. MRO's camera will be capable of identifying objects the size of a basketball, allowing it to identify hazards for future landed missions, as well as locating landers already on the surface.

The Phoenix mission plans to search for water on Mars.

NASA chose the University of Arizona's "Phoenix" mission as its first competed Mars Scout to launch in the 2007 opportunity. Scouts are cost-capped missions that give the Mars science community the opportunity to compete and participate in Mars exploration. Another scout mission may be featured as NASA's 2011 Mars program offering. Like its mythological namesake, Phoenix was born from the canceled Mars Surveyor Program's 2001 (MSP '01) lander mission and the instruments lost on 1998's Mars Polar Lander. Phoenix will target a 65°–75° northern polar region of Mars in search of water in all its phases. The complement of spacecraft and payload is ideally suited to perform a scientific analysis of the martian arctic soils for clues to its geologic history and potential for biology.

Planning is underway for a Mars Science Laboratory mission for the 2009 launch opportunity. NASA proposes to develop and launch a roving long-range, long-duration science laboratory that will be a major leap in surface measurements and pave the way for a future sample return mission. Extending the duration of landed Mars missions is a primary goal of this mission, as it will take advantage of NASA's Prometheus nuclear power program.

WILL MARS SURVIVE?

Will Mars survive this robotic assault? Two out of every three robotic missions dispatched to the Red Planet since the 1960s have ended in failure. Could this be an indication that the martian defense forces are remarkably capable? Or could this signal that our desire to learn the secrets of Mars extends beyond the failures of individual missions? The spacecraft currently racing their way to Mars represent a rich cross-section of the Mars science community. Regardless of which one arrives first, or survives longest, science ends up the big winner.

WEB SITES OF INTEREST

These Web sites will be the primary outlet for anyone interested in monitoring the daily progress of each mission.

Mars Exploration Rover
http://mars.jpl.nasa.gov/mer/

Mars Express Mission/Beagle 2 Lander
http://www.esa.int/SPECIALS/Mars_Express/

Nozomi Mission
http://www.isas.ac.jp/e/enterp/missions/nozomi/

Mars Reconnaissance Orbiter
http://mars.jpl.nasa.gov/mro/

Phoenix Project
http://phoenix.lpl.arizona.edu/

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To be added to the mailing list to receive notification of future issues, please send your address (along with phone, fax, and e-mail), to LPIB Editor, 3600 Bay Area Boulevard, Houston TX 77058-1113, USA, or send an e-mail message to *lpibed@lpi.usra.edu*.

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Resources for Researchers

Sharing Discoveries in Cosmochemistry and Planetary Geosciences

— G. Jeffrey Taylor and Linda M. V. Martel,
University of Hawai'i

www.psrd.hawaii.edu

People will get excited about planetary science only if they know about the ideas and issues — and understand enough about the discoveries to support and care about the results. Bringing attention to cosmochemistry and planetary geosciences is what the Planetary Science Research Discoveries (PSRD) Web site is all about. We want to help people stay on top of the issues. PSRD also aims to be useful to the scientific community. Whether you want a quick way to assimilate new research in or out of your own field or want a way to communicate your own research with the broader scientific community, teachers, students, and public, PSRD provides the ideal format.

How PSRD Operates

The PSRD Web site shares the latest NASA-sponsored research on meteorites, planets, and other solar system bodies by featuring in-depth articles that explain the science and the motivation behind the research. We place an emphasis on astromaterials research and include planetary geology articles to help tie cosmochemistry into the broader scientific picture. Articles are based on work recently published in peer-reviewed journals and are written to convey how the research results are inspiring fundamental discoveries about our solar system. Articles also include bibliographic references and links to primary sources and supplemental material.

In explaining the details, we strive to relate them to the broader questions of "What do we know about how the solar system formed and evolved?" and "Why do we care?" Each article is reviewed prior to publication by appropriate researchers, including the authors of the featured journal article, or by a member of our Editorial Advisory Board, which includes scientists and an education/public outreach professional. The Web site is supported by the Cosmochemistry Program at NASA's Office of Space Science and by the Hawai'i Space Grant Consortium. Founded and operated by the authors of this article, PSRD originates from the Hawai'i Institute of Geophysics and Planetology at the University of Hawai'i.

PSRD maintains a comprehensive archive where articles are grouped under several broad topics including planets, meteorites, asteroids, comets, origins, and issues concerning life on Mars. The site also contains science news links, a glossary, search option, links to classroom activities and NASA planetary missions, and a free subscription option to receive e-mail announcements of each new article.

PSRD has been recognized with achievement awards from the National Academy Press, the National Science Teachers Association, the Physical Sciences Information Gateway, the Teacher Information Network, SpaceViews, and NewScientist, just to name a few. This recognition gives us continuing feedback that our content and style of writing is successful in reaching and educating a broad audience. Another indicator of the value of PSRD is the wide range of Web sites that link to it, including university and public libraries, university departments, professional educator associations (regional and national), educator-created resource lists (college and precollege), student-created resource lists, NASA sites, and Internet directories of sites for space, astronomy, and the geosciences.

Write an Article!

The PSRD Web site is open to all who wish to contribute an article suited for the interdisciplinary nature of planetary science. PSRD provides an effective forum for NASA-funded cosmochemists and planetary scientists to fulfill outreach responsibilities. A key requirement is that PSRD articles are based on scientific work published in recognized, peer-reviewed journals. Submitting an article to PSRD is simple. Articles should be written in English for a general audience, with a minimum of scientific jargon. If you need to use technical language, we will add the terms to our ever-expanding glossary. Write it in the first person. Feel free to add something about your motivation for doing the work. Articles should not exceed about five pages (single-spaced). Begin the article with a one-paragraph summary of the theme and main points. Use PSRD to communicate your research results beyond the scientific community into the broader public arena where more people can learn about and appreciate the new ideas and discoveries in cosmochemistry and planetary science that you help make happen every day.

NASA ASTROPHYSICS DATA SYSTEM ABSTRACT SERVICE

— by Dr. Guenther Eichhorn, ADS Project Scientist

http://adswww.harvard.edu

The NASA ADS Abstract Service is a NASA-funded project that provides free Web-based abstract search services with over 3.5 million records, as well as access to 2.4 million scanned pages from articles of the astronomical literature as far back as articles from the *Astronomische Nachrichten* from 1821.

The 3.5 million references in the abstract service are in four databases:

1. Astronomy and Planetary Sciences (950,000)
2. Physics and Geophysics (1.5 million)
3. Space Instrumentation (690,000)
4. ArXiv Preprints (250,000)

Each database contains abstracts from hundreds of journals, publications, colloquia, symposia, proceedings, Ph.D. theses, and NASA reports. All abstracts can be searched by author, title, or abstract text words.

The 11 mirror sites in France, Germany, Japan, Chile, Britain, India, Russia, Brazil, Argentina, Korea, and China help to provide better global access to the ADS data. Six of these mirror sites provide access to the scanned articles, the others only to the abstract search system.

The ADS Article Service provides free access to the full text of more than 320,000 scientific papers published in astronomical journals, conference proceedings, newsletters, bulletins, and books, for a total of 2.4 million scanned pages. Most astronomy journals have been scanned beginning with their first volume, and free access to these journal articles is provided to all users through the ADS Web site. The ADS Abstract Service provides links to the full text of papers available as scanned documents, as well as electronic articles available online from the publishers' websites.

Recent Geophysics Additions

With the cooperation of the American Geophysical Union, abstracts have been added to the Astronomy and Physics databases from the *Journal of Geophysical Research (JGR)* and other AGU geophysics journals starting in 2002. With the cooperation of the European Geophysical Union, abstracts have been added from the following journals: *Annales Geophysicae*, *Hydrology and Earth System Sciences*, *Nonlinear Processes in Geophysics*, and *Natural Hazards and Earth System Sciences.*

Recently added abstracts include full coverage of the following journals of interest to the planetary community: *Annals of Glaciology*, *Journal of Applied Meteorology*, *Journal of the Atmospheric Sciences*, *Journal of Glaciology*, and *Bulletin of the American Meteorological Society* (vol. 51 to present only). Several new Elsevier and Wiley journals have been added as well.

Meeting Abstracts

Included in the Astronomy database are all the abstracts from the DPS and LPSC meetings. Included in the Physics database are abstracts from the most recent AGU meetings as well as abstracts from most APS meetings back to 1996.

Citations Online

The ADS Abstract Service contains over 13 million citations collected from astronomy journal reference lists. Despite the large numbers, users should be reminded that the citations contained in ADS are incomplete because of the partial coverage of journals used to build the citation database and our inability to verify 100% of references (e.g., works in press, private communications, typographical errors made by authors, and other errors). Anyone using the citations for analysis of publishing records should keep this in mind.

Scanning Summary

The ADS includes full text scans for most astronomy journals. Of particular interest to planetary astronomers are *Earth, Moon and Planets* (including all former titles) and *Celestial Mechanics and Dynamical Astronomy*. Full text scans are also available for many volumes of LPI meeting abstracts, Proceedings of the Lunar and Planetary Science Conferences, LPI Contributions, and LPI Technical Reports. The *Australian Journal of Physics* will soon be available. For a complete list of scanned articles, visit the scanned journals page on the ADS Web site.

Request for Help

ADS would like to include more conference proceedings in the abstract service. If you are the organizer of a conference or the editor of a conference proceedings, please consider providing ADS with the abstracts for your conference or proceedings volume so they can be accessed through the searchable databases.

SPOTLIGHT ON EDUCATION

"Spotlight on Education" highlights events and programs that provide opportunities for space scientists to become involved in education and public outreach and to engage science educators and the community. If you know of space science educational programs or events that should be included, please contact the Lunar and Planetary Institute at outreach@lpi.usra.edu.

CHICAGO 2004: A WORKSHOP TO FOSTER BROADER PARTICIPATION IN NASA SPACE SCIENCE MISSIONS AND RESEARCH PROGRAMS

Space science mission planning spans the next several decades. During this time, substantial turnover in the scientific workforce and changes in national demographics will occur. NASA's Office of Space Science (OSS) has been engaging in ongoing discussions and collaborations with professional societies of minority scientists and minority universities over the past several years in an effort to initiate a coordinated approach to improving diversity in space science. From these discussions, it has become apparent that there is a need to focus on access to space science missions and research for professional-level minority scientists.

Chicago 2004, organized by DePaul University on behalf of the NASA OSS, will bring together current and prospective NASA mission scientists and educators, OSS-funded scientists and educators, and a diverse array of individuals interested in participating in future OSS missions and research programs, including minority university faculty and administrators and members of professional societies of minority underrepresented scientists. The workshop is designed to initiate partnerships among a more diverse community of investigators, and to build a deeper understanding of how the NASA space science missions, programs, and proposals are organized, planned, and undertaken. A primary focus of the workshop is to generate greater involvement of minority universities and underrepresented scientists in missions and programs. For more information about the planning workshop and the Chicago 2004 agenda, logistics, and registration, visit *http://analyzer.depaul.edu/Chicago2004.*

EXPLORE SPACE SCIENCE EDUCATION INVOLVEMENT OPPORTUNITIES AT THE FALL AGU MEETING

A variety of education sessions of interest to the space science community will be presented during the Fall AGU meeting to be held December 8–12, 2003, in San Francisco, California. These sessions provide space scientists with the opportunity to learn about existing programs, discuss successful models of science education, and explore where new programs are needed.

Session details are available at *http://www.agu.org/cgi-bin/sessionsfm03?meeting=fm03&sec=ED.* The following topics will be included:

Astrobiology Education: Bridging the Gap Between Scientists and Educators
Bringing Extrasolar Planets to Teachers, Students, and the Public
Enhancing K–12 Earth Science Education Through Partnership
Fixing the Holes in the Leaky Pipeline (Achieving Gender Balance in the Geosciences)
Earth and Space Science Materials for Students With Special Needs
Conceptions, Cognition, and Change: Student Thinking About the Earth
Exploiting the Electronic Media to Communicate Science
Education and Outreach Efforts of Major Research Facilities and Organizations
The Benefits and Challenges of Education and Public Outreach Efforts Associated with Scientific Research Programs
Interactions with Native American and Tribal Colleges and Universities

TO MARS WITH MER

Passport to Knowledge (P2K) will broadcast a series of documentary specials and live events for the general public associated with the landing and surface operations of NASA's Mars Exploration Rovers. The ongoing "To MARS with MER" project is supported in part by the National Science Foundation and the National Aeronautics and Space Administration. Check your local television listings for air times on participating PBS stations and on NASA Television. Scheduled broadcasts are listed below.

"6 Minutes Over Mars" (Prime time, January 2004, air date to be determined) —
Go behind the scenes for the all-important entry, descent, and landing sequence. Witness years of effort come to a climax in the intricately detailed set of events that will result in the airbag-cushioned landing of "Spirit" in Gusev Crater on January 4, 2004. Meet the men and women who've made it happen, and see their heroic efforts to maximize the odds of mission success.

"First Look" (Saturday, January 17, 2004, 3:00–4:00 p.m. U.S. Eastern Time) —
Just days after the first touchdown, this interactive program* airs live from the Houston Museum of Natural Science in Texas and the NASA Jet Propulsion Laboratory in California. The program will be

hosted by Bill Nye the Science Guy, who is a co-investigator on the MER mission. Onsite or online visitors can interact with mission scientists and other experts about the latest pictures and information. The risky landing of "Spirit" will be given a sports-style "play-by-play," with the very latest images from the surface, and the upcoming January 25 landing of the second rover, "Opportunity," is previewed. For more information on the program, visit the Web site at *http://passporttoknowledge.com/mars/involved/look.html*.

"New Views" (Saturday, May 1, 2004, 3:00–4:00 p.m. U.S. Eastern Time) —
"New Views" shares the first scientific results from the MER mission after three months of surface operations have been completed. Is there evidence of past liquid water at the landing sites? What do the first findings imply for the possibility of past life on Mars? This interactive program* airs live from the St. Louis Science Center in Missouri and the NASA Jet Propulsion Laboratory in California. More information on the program is available at *http://passporttoknowledge.com/mars/involved/view.html*.

"Following the Water" (Prime time, spring/summer 2004, air date to be determined) —
The rover missions are part of a long-term strategy to characterize the past martian climate by discovering the history of water on the planet. What did the two different landing sites reveal? When did liquid water last flow on the surface: long ago, or much more recently? What's the latest thinking about the habitability of Mars at that time? And how do the MER findings relate to future missions: the Mars Reconnaissance orbiter, the Mobile Science Laboratory, and "Phoenix," all of which are due to land on the polar ice cap later this decade.

* During "First Look" and "New Views," viewers can monitor the events by streaming video via NASA's Classroom of the Future Web portal. Participants can send questions via e-mail, and receive instant answers from NASA researchers and Mars experts. Information on how to access the broadcasts, as well as mission overviews, content, classroom lesson plans, resources, and student pages can be found at *http://passporttoknowledge.com/mars*. NASA and JPL materials on Mars and the rover mission are also available in Spanish.

THE TRANSIT OF VENUS

The silhouette of Venus will cross the face of the Sun as seen from the Earth on June 8, 2004, for the first time since 1882!

The Transit of Venus will be the theme of Sun-Earth Day 2004, sponsored by the Sun-Earth Connection Forum. Opportunities for involvement by researchers, educators, students, and the general public include:

- ✧ March 19, 2004, Web cast to prepare students, parents, and museums for safe viewing of the transit of Venus
- ✧ June 8, 2004 real-time Web cast of the entire transit starting at 1:00 a.m. (EDT) Tuesday and ending 7:30 a.m.
- ✧ Access to classroom math, geometry, reading, and science activities based on the real-time data
- ✧ "Ask the Scientist" chat rooms and e-mail opportunities
- ✧ Solar Week, for students to learn about careers in space science
- ✧ John Philip Sousa's *Transit of Venus March* first reperformance

Activities, lesson plans, background, resources, and presentations focused on history, music, technology, math, and astronomy allow formal and informal educators and scientists to create events or participate in one of the opportunities available through the Sun-Earth Connection. Comparisons of Venus with Earth and Mars, calculations of the distances to nearby stars, and the use of transits to identify extrasolar planets add to the excitement of this cosmic occurrence. To learn more, and to access supporting resources for these events and others, visit *http://sunearth.gsfc.nasa.gov/sunearthday/2004/index_vthome.htm*.

STUDENT OBSERVATION NETWORK

Students track solar storms from start to finish through the Student Observation Network. The Network challenges students to observe, measure, and analyze solar storm-related phenomena — sunspot distribution, radio wave intensity, changes in the magnetosphere, and auroras — and to compare their findings with those of observatories and NASA satellites.

The Student Observation Network, facilitated by the Sun-Earth Connection, offers opportunities for educators and researchers to involve students in solar storm tracking. Students make observations, compare them to research-based observation programs, and submit their data to the Student Observation Network for access by participating classrooms. Tutorials are provided for facilitators. Support includes information concerning accessing necessary equipment or constructing inexpensive measurement tools, content, and resources. To learn more about the Student Observation Network, visit the Web site at *http://sunearth.gsfc.nasa.gov/son*.

Interested in becoming more involved in space science education and public outreach? NASA's OSS Support Network encompasses a nationwide network of Broker/Facilitators and Education Forums that are prepared to assist space science investigators in developing high-quality, high-impact E/PO programs. For more information about the network, or to contact the Broker/Facilitator in your region, please visit http://spacescience.nasa.gov/education/index.htm.

News from Space

Sunlight Makes Asteroids Spin in Strange Ways

A new study published in the September 11 issue of *Nature* has found that sunlight can have surprisingly important effects on the spins of small asteroids, perhaps a more important role in determining asteroid spin rates than collisions. David Vokrouhlický (Charles University, Prague) and David Nesvorný and William Bottke (Southwest Research Institute, Boulder) conducted the study, which showed that sunlight absorbed and reemitted over millions to billions of years can spin some asteroids so fast they could potentially break apart, or nearly stop them from spinning altogether. The team even noted that the effects of sunlight, combined with the gravitational tugs of the planets, can slowly force asteroid rotation poles to point in the same direction.

Until recently, researchers thought asteroid impacts controlled the rotation speed and direction of small asteroids floating in space. The unusual spin states of 10 asteroids observed by Stephen Slivan, a researcher at the Massachusetts Institute of Technology, however, have cast doubt on this idea. These 10 asteroids are in the so-called Koronis asteroid family, a cluster of asteroid fragments produced by a highly energetic collision billions of years ago. Slivan found that not only do four of these asteroids rotate at nearly the same speed, but they also have spin axes that point in the same direction. Vokrouhlický, Nesvorný, and Bottke investigated how asteroids reflect and absorb light from the Sun and reradiate this energy away as heat. They found that while the recoil force produced by the reradiation of sunlight is tiny, it can still substantially alter an asteroid's rotation rate and pole direction if it has enough time to act.

"Like the story about the tortoise and the hare, slow and steady sunlight wins the race over the fast-acting, but less effective, jolt of collisions between asteroids. Sunlight in space never stops," says Bottke, "and most asteroids have been exposed to a lot of it because of their age."

Farthest, Faintest Solar System Objects Found Beyond Neptune

Astronomers using NASA's Hubble Space Telescope have discovered three of the faintest and smallest objects ever detected beyond Neptune. Each object is a lump of ice and rock — roughly the size of the city of Philadelphia — orbiting beyond Neptune and Pluto in a ring-shaped region called the Kuiper belt, which houses a swarm of leftover building blocks, or "planetesimals," from the solar system's creation.

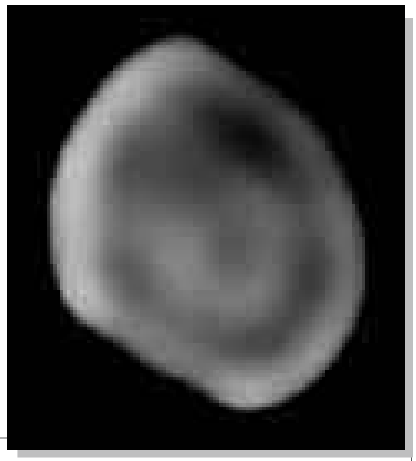
The study's big surprise is that so few Kuiper belt members were discovered. Hubble's Advanced Camera for Surveys was pointed at a region in the constellation Virgo over a 15-day period in January and February 2003. A bank of 10 computers on the ground worked for six months searching for faint-moving spots in the Hubble images. With Hubble's exquisite resolution, astronomer Gary Bernstein of the University of Pennsylvania and his co-workers expected to find at least 60 Kuiper belt members as small as 15 kilometers (10 miles) in diameter, but only three were discovered.

"Discovering many fewer Kuiper belt objects than was predicted makes it difficult to understand how so many comets appear near Earth, since many comets were thought to originate in the Kuiper belt," Bernstein says. "This is a sign that perhaps the smaller planetesimals have been shattered into dust by colliding with each other over the past few billion years."

Asteroids Have Deep Pockets Taken Out of Them

A team of scientists have made the first full-rotational, groundbased observations of asteroid (511) Davida, a large, main-belt asteroid 320 kilometers (200 miles) across. These observations are made possible only through the use of adaptive optics on large telescopes. Adaptive optics enables astronomers to compensate for the distortion created by air currents in our planet's atmosphere, yielding images as sharp and clear as those taken in space.The observations of asteroid (511) Davida were made with the 10-meter (400-inch) Keck II telescope on December 26, 2002. The high angular resolution allowed astronomers to see surface details as small as 46 kilometers (30 miles), about the size of the San Francisco Bay area, although only the northern hemisphere was visible. Yet the profile of the asteroid is far from circular: At least two flat facets can be seen on its surface.

By combining modern technology with a historical telescope, astronomers have discovered that the asteroid Juno also has a "bite" taken out of it. The first direct images of the surface of Juno show that it is scarred by a fresh impact crater. Juno, the third asteroid ever discovered, was first spotted by astronomers early in the nineteenth century. One of the largest asteroids, at a size of 240 kilometers (150 miles) across, Juno essentially is a leftover building block of the solar system.



Asteroid (511) Davida displays features on its edges. Photo courtesy of Keck Observatory.

This artist's rendition of asteroid 3 Juno shows the "bite" taken out of the asteroid by an impact. Courtesy of David Aguilar, Harvard-Smithsonian Center for Astrophysics.

Astronomer Sallie Baliunas (Harvard-Smithsonian Center for Astrophysics) and colleagues, writing in the May 2003 issue of *Icarus*, used an adaptive optics system connected to the 2.5-meter (100-inch) Hooker telescope at Mount Wilson Observatory. Their images showed that Juno, like other asteroids, is misshapen rather than round, and that it has "sharp" edges. Even better, as Juno tumbled through space during the night of observing, a "bite" came into view. The astronomers concluded that the asteroid had recently (in astronomical terms) collided with another object, resulting in a crater 97 kilometers (60 miles) wide.

"I look at an asteroid as a garden — a garden not of flowers and leaves, but one of rubble and dust churned up by constant impacts. This process of gardening pulverizes the asteroid's surface into a fine-grained regolith," said Baliunas. "The recent, large impact on Juno gives us an opportunity to see through the regolith and study excavated material from beneath the surface — a rare look into the material out of which the early Earth was formed."

Thus Davida and Juno join Vesta and Matilda as large asteroids with big holes. Apparently, asteroids can take quite a wallop and remain intact. The blast that knocked a bite out of Juno may also have provided researchers with a convenient way of studying that asteroid up close without ever leaving our planet. Some meteorites found on the Earth are actually pieces of large asteroids like Juno and Vesta. Those pieces were broken off and launched into space by an impact, and a few of these later fell on our planet. The newly found impact crater on Juno may have sent samples of that asteroid to the Earth.

Important Reminder

Dear Readers,

Remember that this is the last issue of the *Lunar and Planetary Information Bulletin* that will be published in both hardcopy and electronic formats. The electronic version of the *Bulletin* will continue to be published and will be available on the LPI's Web site at

http://www.lpi.usra.edu/lpib/

Issues are published in PDF format, viewable with the Adobe Acrobat Reader (available free of charge from http://www.adobe.com). The electronic versions include full-color versions of many of the exciting images featured in the newsletter, as well as links to the many Web sites mentioned in the articles and a link to previous issues of the *Bulletin*.

Reminder notices will be sent out as each issue becomes available on line. We realize that this may present an inconvenience to some of our readers, and will make every effort to continue to serve our readership as efficiently as possible. If you do not have Web access, but would like to continue to be able to read the quarterly issues of the *Bulletin*, please contact our staff at lpibed@lpi.usra.edu.

Sincerely,
Editorial Staff, *Lunar and Planetary Information Bulletin*

Solicitation for Contributions

Contributions to the *Lunar and Planetary Information Bulletin (LPIB)* are solicited from the planetary community and beyond. Articles exploring issues related to planetary science and exploration are welcome. Of special interest are articles describing Web-based research and educational tools (such as those described in the current issue) and new space missions that may be of interest to our readers. The *LPIB* is published quarterly and serves the planetary research community, science libraries, educators, students, and lay readers interested in space-science-related research. Suggested topics can be e-mailed to the editors, who will provide guidelines for formatting and content.

Dr. Paul Schenk
Scientific Editor (schenk@lpi.usra.edu)
Renée Dotson
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NEW AND NOTEWORTHY

These products are available from booksellers or the publisher listed.
Please note that the LPI does not offer these products through its Order Department.

BOOKS

Mars Observer's Guide: A Practical Handbook for Amateur Astronomers. By Neil Bone. Firefly Books Ltd., 2003. 160 pp., Paperback, $14.95. *www.fireflybooks.com*

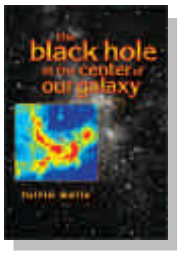
In the year 2003, Mars has been closer to Earth than ever, presenting an excellent (and rare) opportunity to observe the Red Planet. This resource created for the amateur astronomer covers everything needed to know to make the most of this unique occurrence. The book describes what equipment is needed to observe Mars and explains the various methods of recording what you can see, from simple sketches to CCD (charge-coupled device) imaging. The book goes beyond being an observational guide with a general introduction to Mars, with descriptions and illustrations of Mars' structure and key physical features. Other topics include the history of Mars observation, the various past space missions to Mars and possible future missions, and the possibility of life on Mars.

Worlds Beyond: The Thrill of Planetary Exploration as Told by Leading Experts. By S. Alan Stern. Cambridge University Press, 2003. 174 pp., Paperback, $21.00. *www.cup.org*

With the development of space travel, we are exploring worlds beyond Earth. Ten planetary scientists describe their favorite planet, what they have discovered, and what drives them to explore. Each tells a personal story, ranging across the breadth of the solar system — from hellish Mercury to the snows of Pluto, from telescopic to robotic exploration, from adventures in Antarctica to painting planetary landscapes, from the frustration of failure to the joy of success.

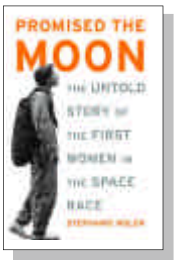
Masks of the Universe: Changing Ideas on the Nature of the Cosmos, Second Edition. By Edward Harrison. Cambridge University Press, 2003. 342 pp., Hardcover, $30.00. *www.cup.org*

What is the universe? History shows that in every age society constructs its own universe, believing it to be the real and final one. Yet these are only models, or masks covering what is not understood and not known. This book brings together fundamental scientific, philosophical, and religious issues in cosmology, raising thought-provoking questions. In every age people have pitied the universes of their ancestors, convinced that they have at last discovered the full truth. Do we now stand at the threshold of knowing everything, or will our latest model also be rejected by our descendants?



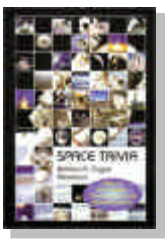
The Black Hole at the Center of Our Galaxy. By Fulvio Melia. Princeton University Press, 2003. 204 pp., Hardcover, $29.95. *pup.princeton.edu*

With this nontechnical account of the most enigmatic astronomical object yet observed, Fulvio Melia captures all the excitement of the growing realization that we are on the verge of actually seeing a supermassive black hole in the center of the Milky Way within the next few years. This book brings together a specific and fascinating astronomical subject — black holes — with a top researcher to provide both amateur astronomers and professional scientists a concise overview of the topic.



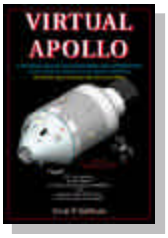
Promised the Moon: The Untold Story of the First Women in the Space Race. By Stephanie Nolen. Four Walls Eight Windows, 2003. 378 pp., Hardcover, $22.95. *www.4w8w.com*

In the early 1960s, 13 American women were invited to take the same battery of tests as the male astronauts known as the Mercury 7 crew. These women were experienced pilots, ready to serve their country, and they all passed — sometimes outdoing their male counterparts. They assumed that they were being considered by NASA for the space program. Thanks to the cultural and political climate of the times and a society that couldn't abide the idea of women in space, astrophysicist Sally Ride would be the first American woman in space in 1983, and Eileen Collins would be the first to take the controls of an American spacecraft in 1994 — some 20 and 30 years after the 13 "Fellow Lady Astronaut Trainees" had all but abandoned their dreams of spaceflight. This book investigates the events surrounding this little-known chapter in history through interviews with the eleven surviving women, detailing their lives and struggles at home and on the job.



Space Trivia. By William Pogue. Apogee Books, 2003. 156 pp., Paperback, $17.95. *www.cgpublishing.org*

What city turned its lights on and off to signal an astronaut? Which astronaut was born in China? Who got the first haircut in space? Which space shuttle never made it into orbit? According to their psychologist, what one thing did the first seven astronauts fear? Written by astronaut William Pogue, Space Trivia spans the period from the Mercury project of the early 1960s right up to the current shuttle/space station era. Obvious and obscure facts provide the basis for this book, which contains 800 questions and answers and a comprehensive index.



Virtual Apollo: A Pictorial Essay of the Engineering and Construction of the Apollo Command and Service Modules. By Scott P. Sullivan. Apogee Books, 2002. 128 pp., Paperback, $26.95. *www.cgpublishing.com*

For the first time the public can become acquainted with the Apollo spacecraft in detail and learn the story of its design and construction. Full-color drawings provide interior and exterior views of the Command and Service Modules, along with details of construction and fabrication. With the exception of Apollo 13, the spacecraft lived up to expectations on every lunar mission. Even Apollo 13, after a major explosion, managed to circle the Moon and bring its crew home safely. This book presents the magnificent machine that was the Apollo spacecraft and the achievements of the thousands of engineers and technicians who stayed on Earth but were on the mission every step of the way.

ONLINE RESOURCES

Web Sites for College Astronomy Instructors
www.astrosociety.org/education/resources/educsites.html

This listing at the Astronomical Society of the Pacific Web site is designed to provide instructors who teach introductory astronomy classes for non-science majors with materials that will help their teaching effectiveness. It is not a comprehensive list, but rather highlights a number of sites that experienced teachers around the country have found useful. Subject-specific or instrument-specific sites are not listed, but only those that come in handy for figuring out how to teach rather than what to teach. Suggestions for sites of general interest to add are welcome.

NEW FOR KIDS

JUST IN TIME FOR THE HOLIDAYS!

Toys and Games

AirZooka. Available from AirZooka.NET, 2003. Ages 6 to adult, $12.99. www.airzooka.net

First displayed in February 2003 at the American International Toy Fair in New York, the AirZooka is one of the hottest toys of the year. The AirZooka shoots rings of air that maintain their cohesiveness until they impact an object, demonstrating the physics of vortex rings. The AirZooka is 100% safe and is available in black, blue, orange, red, and yellow.

Race to the Planets Game. By Family Astro, Astronomical Society of the Pacific, 2003. Fourth grade and up, $15.95. www.astrosociety.org/online-store/scstore/

Baked by the sun? What planet is this? Slip your question card into the decoder and you're in the race. Be the first player to collect seven different planets on your Frequent Flyer card, and you win the Race to the Planets, a new family game from Family ASTRO.

Moon Mission: A Cooperative Family Board Game. By Family Astro, Astronomical Society of the Pacific, 2003. For 2–4 players, ages 8 to adult, $15.95. www.astrosociety.org/online-store/scstore/

Race against time in this new board game for the whole family. In an effort to retrieve damaged instruments scattered across the lunar landscape, players must work together to accomplish their mission and get everyone safely back to Grimaldi Moon Base before the long lunar night falls (day and night on the Moon each last about 15 Earth days). Success depends on players developing a joint strategy, understanding conditions on the Moon, and a bit of luck. Developed as part of a national family astronomy program, Moon Mission is available exclusively online and includes a chance to give the game's designers your input.

Spaceopoly: The Space-Age Real Estate Game. By Valen Brost Game Company. For 2–4 players, ages 8 to adult, $14.99.

Fasten your seat belt, roll the dice, and begin your fantasy voyage into the far reaches of our solar system. To build your financial empire, your mission is to build monopolies within the planet systems. Complete a special assignment while avoiding bankruptcy and the many perils of space travel. This Mars edition includes a special mission to the Red Planet!

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Calendar 2003–2004

Information was valid as of this issue's publication and is subject to change without notice. For more information see the Web sites listed.

November

2–5 **Geological Society of America Fall Meeting,** Seattle, Washington. *http://www.geosociety.org/meetings/2003*

10–14 **30th International Symposium on Remote Sensing of Environment,** Honolulu, Hawaii. *http://isrse.pdc.org/*

16–22 **International Lunar Conference 2003,** Kohala Coast, Hawai'i Island, Hawai'i. *http://www.spaceagepub.com/ilc_2003.html*

17–23 **IAU Colloquium 194 "Compact Binaries in the Galaxy and Beyond,"** La Paz, Mexico. *http://www.astrosen.unam.mx/~iau194/casatest.html*

18–19 **American Astronautical Society National Conference and 50th Annual Meeting,** Houston, Texas. *http://www.astronautical.org/*

18–20 **The Third European Expo on Astrobiology: Mars, the Search for Life,** Madrid, Spain. *http://www.cab.inta.es/workshop03/Main_V2.htm*

December

2–4 **37th ESLAB Symposium: Tools and Technologies for Future Planetary Exploration,** Noordwijk, The Netherlands. *http://astro.estec.esa.nl/Resources/conferences/Eslab37/*

8–11 **Hypervelocity Impact Symposium,** Noordwijk, The Netherlands. *http://www.estec.esa.nl/conferences/hvis2003/*

8–12 **American Geophysical Union Fall Meeting,** San Francisco, California. *http://www.agu.org/meetings/fm03/*

January 2004

2–4 **Planetfest '04, Pasadena,** California. *http://www.planetary.org/planetfest04/*

4–8 **203rd Meeting of the American Astronomical Society,** Atlanta, Georgia. *http://www.aas.org/*

5–8 **AIAA Aerospace Sciences 42nd Meeting,** Reno, Nevada. *http://www.aiaa.org/calendar/*

11–15 **Symposium on Space Weather,** Seattle, Washington. *http://www.ametsoc.org/*

15–18 **2004 Hawaii International Conference on Sciences,** Honolulu, Hawaii. *http://www.hicsciences.org/*

24–28 **American Association of Physics Teachers, 128th National Convention,** Miami, Florida. *http://www.aapt.org/Events/calendar.cfm*

February

6–8 **Workshop on Europa's Icy Shell: Past, Present, and Future,** Houston, Texas. *http://www.lpi.usra.edu/meetings/europa2004*

9–13 **Conference on Sun-Earth Connections: Multiscale Coupling in Sun-Earth Processes,** Kona, Hawai'i. *http://csec.jhuapl.edu/*

16–17 **The Impact of Active Galaxies on the Universe at Large,** London, UK. *http://www.astro.physics.ox.ac.uk/~kmb/royalsocietydm.html*

18 **Space at the Crossroads,** Washington, DC. *http://www.spacecrossroads.org/*

23–26 **2004 Planetary Defense Conference: Protecting Earth from Asteroids,** Garden Grove, California. *http://www.leonidstorm.com/conferences/planetdef/*

March

7–10 **Earth & Space 2004: 9th ASCE Aerospace Division International Conference on Engineering, Construction and Operations in Challenging Environments,** Houston, Texas. *http://www.asce.org/conferences/space04*

15–19 **35th Lunar and Planetary Science Conference,** League City, Texas. *http://www.lpi.usra.edu/meetings/lpsc2004*

28–April 1 **Astrobiology Science Conference 2004 (AbSciCon),** Moffet Field, California. *http://abscicon2004.arc.nasa.gov/*

29–April1 **National Space Symposium,** Colorado Springs, Colorado. *http://spacesymposium.org/national04/*

29–April 2 **Royal Astronomical Society National Astronomy Meeting,** Milton Keynes, UK. *http://physics.open.ac.uk/NAM/*

A list of other meetings of interest to the community is also available on the LPI's Web site at www.lpi.usra.edu/meetings.