# The PLANETARY REPORT

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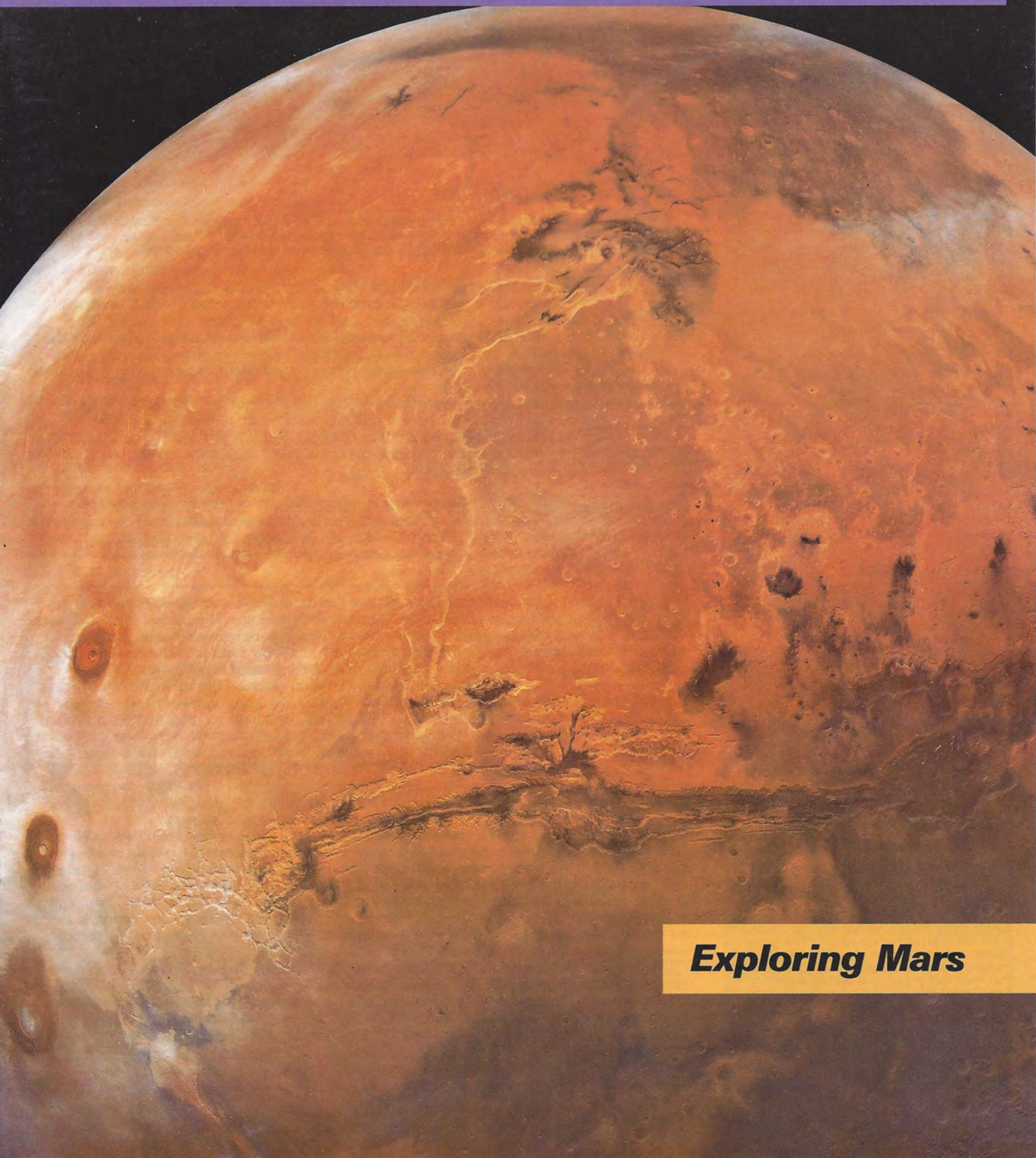

## Exploring Mars

*A Publication of*
# THE PLANETARY SOCIETY



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***COVER: Nearly an entire hemisphere of Mars appears in this enhanced color mosaic compiled from images taken by the Viking 1 orbiter. The great canyon Valles Marineris cuts across the lower center of the mosaic, from Noctis Labyrinthus on the left to the chaotic terrain on the right. Three massive volcanos — Arsia Mons, Pavonis Mons and Ascraeus Mons (from lower left to upper right) — rise 17 kilometers from the surrounding plains. Computer manipulations such as this allow scientists to extract new information from old data, but to significantly advance our understanding of Mars we must again visit the Red Planet.***
***Image: Alfred S. McEwen, United States Geological Survey***

## Letters to the Editor

***We encourage our members to write to us on topics related to the goals of The Planetary Society: Continuing planetary exploration and the search for extraterrestrial life.***
***Address them to: Letters to the Editor, 65 N. Catalina Avenue, Pasadena, CA 91106.***

In reponse to W. H. Aaroe's letter (in the November/December 1986 issue of *The Planetary Report*), I do agree that the United States is becoming a "trash dump." However, I strongly disagree with his conclusion that we must scrap a mission to Mars if we are to clean up our environment.

It is through just such space and planetary explorations and studies that we gain insight into the mechanics of our own Earth and are therefore better able to manage our planet. We have, in fact, made several important changes in the management of our natural resources as the direct and indirect results of past explorations and studies.

While I do not pretend that a mission to Mars will solve our problems on Earth, by the same token I do not understand why we must give up the Mars mission if we are to clean up our planet. A mission to Mars, as outlined in past issues of *The Planetary Report*, is of a fairly modest cost and could easily coexist in the federal budget with programs of waste control and cleanup.
TYRONE LEIN, *Fort Atkinson, Wisconsin*

One of the great services of *The Planetary Report* is its publication of recently reprocessed color images of the planets — especially Mars. There is a great deal more information, and beauty, in these pictures than was realized when the *Viking* mission was flown more than a decade ago, and it is a pleasure to look forward to seeing these "new" photos appear in your excellent magazine.
DAVID MORRISON, *University of Hawaii*

Last April, I toured the Kennedy Space Center at Cape Canaveral. The Center looked like a Space Age relic, with gantries and rockets rusting away in the salt air of the Cape. The saddest sight of all was the *Saturn V* Moon rocket lying flat on the ground. The launch pads were empty. The US space program seemed nothing more than a footnote in American history that said: "This is where our astronauts, satellites and space probes were launched back in the Space Age."

During the tour, I visited a mock-up of the *Apollo* Program's Mission Control room. As I gazed at the vacant rows of silent monitors, I recalled the day *Apollo 11* landed on the Moon. I was a 23-year-old medical student when on that eventful day in July 1969, right there on black and white TV I saw Neil Armstrong step on the Moon. With great anticipation, I clumsily took 10 very blurred pictures of the event. I even made a crude audiotape of Armstrong's "giant leap" announcement. I turned to my younger brother and told him how much I envied the children of the 21st century. They would surely be thriving in colonies on the Moon, Mars and elsewhere in space. The possibilities of space exploration seemed limitless. I was proud to be a witness to the dawn of the Space Age. Little did I realize that 17 years later I would also witness its twilight with the demise of *Challenger*.

While at the Space Center, I toured several exhibits of Space Age hardware including the *Mercury* and *Gemini* capsules, *Apollo*'s lunar and command modules and segments of the Moon rocket. I had this awful feeling that I was looking at America's past, not its future. I was in a museum. A young child excitedly pointed at the gleaming gold-plated lunar module and asked his father: "What's that, Dad?" His father enthusiastically responded: "Our astronauts landed on the Moon in that!" I suddenly realized that today, nobody under the age of 14 was even alive during the last *Apollo* mission. In fact, we have a whole generation of children and adolescents who have never experienced the thrill of watching a manned mission to the Moon. It is all history to them.

I stood in line nearly a half hour for tickets to see these exhibits. The museum was packed with enthusiastic children and adults of all ages. If America has lost its interest in space, then nobody has told these people. Exploration and discovery are woven into the very fabric of our society. In order to regain our pride, we must revitalize the moribund US space program. We owe it to our children and their descendants. To do this, we must return to the Moon and Mars, and then journey outward into the solar system.
ALFORD S. KARAYUSUF, M.D., *Saint Paul, Minnesota*

# Radiation Risk and Planetary Exploration— The RTG Controversy

**by David F. Salisbury**

Take the aftermath of the *Challenger* disaster. Combine it with the continuing public concern over radioactive contamination, recently reinforced by the accident at the Soviet nuclear reactor in Chernobyl. The product is an ongoing political debate that poses a significant threat to the future of the US planetary exploration program.

At issue is the risk of using spacecraft powered by radioisotopic thermoelectric generators, or RTGs. These are plutonium-fueled electric power units that have been used on five *Apollo* missions and six planetary probes without incident (the RTG on the ill-fated *Apollo 13* fell into the ocean).

The *Challenger* explosion forcefully brought home the reality of the dangers that remain in space operations. As a result, practices that had been accepted as routine are undergoing increased scrutiny, both technical and political.

The RTG controversy was touched off by an article published in *Common Cause* magazine last summer. The article dealt primarily with the battle that Karl Grossman, a journalism professor at the State University of New York, waged to obtain inappropriately classified information from the Department of Energy about the consequences of a shuttle accident involving RTGs. But it also left the reader with the misleading impression that such an accident could cause hundreds of thousands of cases of cancer, or worse.

The first planetary missions possibly affected are *Galileo* and *Ulysses*.

### Galileo and Ulysses

The *Galileo* mission is designed to send an orbiter and atmospheric probe to study Jupiter and its satellites. To do so, NASA built the most technically complex spacecraft ever designed for outer solar system exploration. Originally called the Jupiter-orbiter-probe (JOP), planning for *Galileo* began in 1977.

Despite its designation as a top-priority planetary mission, *Galileo* has been delayed by budget cuts, even threatened with cancellation. In the course of development, the spacecraft has been repeatedly redesigned to accommodate changes in the shuttle's upper stage. During a 19-month period in the early 1980s, Congress changed the upper stage from a planned three-stage, solid-fueled rocket then called the Interim Upper Stage (the IUS is now called the Inertial Upper Stage) to a liquid-fueled *Centaur* booster modified for the shuttle, then to a two-stage, Air Force version of the IUS and then back to the *Centaur*.

*Ulysses* is a European Space Agency (ESA) craft. Its purpose includes the exploration of the Sun's never-before-examined polar regions. When launched, it will provide greatly improved latitude-dependent data on a number of solar properties. These include the boundary between the solar surface and the solar wind, magnetic field strength, x-ray and cosmic ray production.

The spacecraft represents the European half of a joint NASA/ESA mission originally approved in 1977. Stretch-outs in the shuttle development program forced NASA to postpone its launch until 1986. Then cutbacks hastily implemented by the Reagan administration caused NASA to cancel its participation, precipitating a storm of international criticism.

### Radioisotopic Thermoelectric Generators

The electrical requirements of both *Galileo* and *Ulysses* are supplied by a simple nuclear power plant, the RTG. The RTG's power source is a series of golf-ball-sized cylinders of plutonium-238, a short-lived isotope of plutonium with a half-life of 88 years. The radioactive decay creates heat which solid state devices convert into electricity. →

## Nuclear-Powered Satellites

*Satellites with nuclear power sources and orbiting space debris, most launched by the Soviet Union, pose a growing threat to other spacecraft and represent a potential source of atmospheric contamination.*

*"There are four dozen potentially dangerous radioactive satellites orbiting the Earth today. Currently planned launches will vastly increase their number, resulting in over three metric tons of fuel and fission products in orbit by the year 2000," according to a 1986 study on the subject authored by Nicholas L. Johnson, an advisory scientist at Teledyne Brown Engineering.*

*Since 1967, the Soviets have launched 30 nuclear-powered radar ocean surveillance spacecraft into low Earth orbit to track US Navy and Allied shipping. Of these, 27 later maneuvered their hazardous reactors into higher storage orbits where they would not return to Earth for several hundred years, but where a growing collision hazard exists.*

*Soviet failures may have caused as many as six nuclear-powered satellites to fall back to Earth. A number crashed into the Pacific Ocean largely intact. But when* Cosmos 954 *malfunctioned in 1977 it spread nuclear debris over a large area in northern Canada. While this accident doesn't appear to have posed much hazard to individuals, it did set off an international furor that caused the Soviets to redesign their spacecraft so that the fuel core can be separated from the reactor. As a result, in future accidents nuclear material is expected to dissipate in the atmosphere rather than survive reentry intact.*

*The details of Soviet space reactor systems are secret. However, they are thought to carry about 50 kilograms of Uranium 235. While this is over twice the mass of the plutonium contained in* Galileo*'s RTGs, it represents less than a millionth of the radioactivity level. Once the reactor is activated in orbit, however, it begins generating highly radioactive fission products, including plutonium. Just how "hot" such a reactor gets depends on its design and how long it is operated. If the reactor is successfully placed in a 400- to 500-year parking orbit, by the time it reenters Earth's atmosphere, it will have cooled down again and its residual activity will come primarily from the uranium and plutonium that remain.*

*Johnson suggests that it is both necessary and feasible to retrieve the majority of nuclear supplies in orbit. However, there are currently no plans for this by either the US or the USSR. And the present American design of the Strategic Defense Initiative ("Star Wars") envisions between hundreds and thousands of orbiting nuclear reactors more powerful than any yet flown.* □

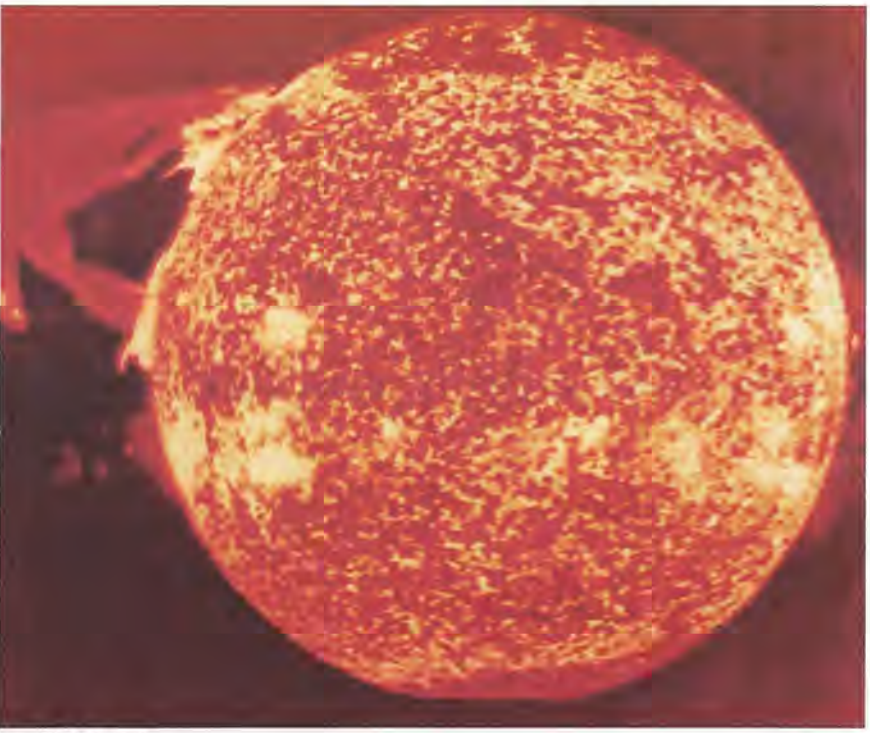
Such generators have many advantages for space applications. They are light and compact. They work well in high radiation environments like those frequently found in outer space. They are long-lived and have proven highly reliable.

Today's RTGs are products of a long development process. They date back to the beginning of the space program. Since 1961, the US has launched 22 RTG-equipped spacecraft. Of these, three have been in accidents.

The first mishap occurred in 1964. A booster malfunction prevented orbital insertion of an RTG-powered Navy navigational satellite. It was lost over the Indian Ocean. Burning up, it added about 15 percent to the radioactive burden of plutonium in the southern hemisphere created by atom bomb testing in previous years. (All atmospheric testing by the United States and the Soviet Union was halted by the 1963 Limited Test Ban Treaty.)

The accident caused the Atomic Energy Commission to rethink its design philosophy. Rather than building the power units and their radioactive fuel to burn up in the atmosphere, AEC experts drastically redesigned them to survive reentry. In addition, an extensive survivability test program was begun.

Since then there have been two further accidents. In 1968, the launch of a meterological satellite was aborted at 30 kilometers altitude. The RTGs were dumped in the ocean but were recovered intact. When the *Apollo 13* astronauts returned safely, despite damage to their spacecraft, the lunar module with an RTG attached burned up over the South Pacific. Follow-up surveys of the area found no evidence that radioactive material had been released.



***The thermonuclear fires of the Sun make life on Earth possible, and study of this nearest star is crucial to understanding the solar system. Ulysses will observe the Sun's never-before-seen polar regions. Image: NASA***

The current generator design consists of a column of 18 modules. Each module includes an aeroshell, two impact shells, carbon fiber insulators and four plutonium fuel elements clad with iridium metal. The aeroshell and the impact shells are made of material developed for the nose cones of ballistic missiles.

The aeroshell is designed to protect the unit during accidental reentry. The impact shells cushion the fuel against damage from flying fragments or ground impact. The insulators protect the fuel from excessive temperatures due to explosion or reentry. The iridium cladding is designed to protect the fuel if the unit is ruptured.

## Probabilistic Risk Assessment

RTGs have survived launch accidents and reentry from orbit. But what assurance is there that they can survive an accident on the space shuttle?

The answer to that question is half science and half art. It involves a technique called Probabilistic Risk Assessment (PRA). You might describe PRA as a scientific attempt at fortune telling. Certainly, the purpose is similar: to predict what will happen in situations before they arise. Of course, PRA employs logic, statistics and engineering, not tarot cards or tea leaves.

Such an analysis begins when a group of experts tries to list all the conceivable ways that a complex mechanism such as the space shuttle can fail catastrophically. Using existing data where available, and "guess-timates" where they are not, the experts assign a probability to each of the significant accident sequences that they identify.

Generally, the scenarios converge on a limited number of failure modes. In the case of the shuttle/*Centaur*, for instance, NASA experts identified five specific explosion types. To determine the likelihood of one type of explosion, experts add together the odds of all the accident sequences that can lead to it.

Once this is done, the location and size of each type of explosion is calculated. For RTG-related accidents, the conditions that such explosions will create at the location of the generators are estimated. Then the explosion's effect on the unit can be determined and, in the case that plutonium may be released, the possible health effects are calculated.

PRA is becoming increasingly valuable in attempts to improve the safety of inherently dangerous technologies. It allows systematic comparison of the relative safety of different designs. But, as a number of experts have pointed out, its strength is in assessing relative, not absolute risk. Nevertheless, NASA and DOE officials have repeatedly treated PRA and actuarial risk (as determined by the insurance industry) as comparable. For instance, they have compared PRA estimates of the odds of a shuttle catastrophe with the risk of dying in an automobile accident (1 in 10,000) or being electrocuted (1 in 1,000,000) or killed by lightning (1 in 10,000,000). Unfortunately, the two types of estimates are generated in an entirely different way and comparisons are extremely risky. Two pre-*Challenger* studies illustrate the problem.

Using the PRA approach, NASA put the odds of a shuttle catastrophe at 1 in 100,000 per launch. It provided a basis for space agency officials to contend that the risks involved were low enough so that politicians and school teachers could fly into space.

In 1983, Sierra Energy & Risk Assessment conducted an actuarially based analysis for the Air Force that came to quite a different conclusion. Based on an analysis of over 2,000 solid rocket launches, the study estimated that the odds of a failure of one of the shuttle's two solid rocket boosters (SRBs) were 1 in 35 per launch. "The message is fundamentally that it's a very risky venture," says the company's president, Robert K. Weatherwax.

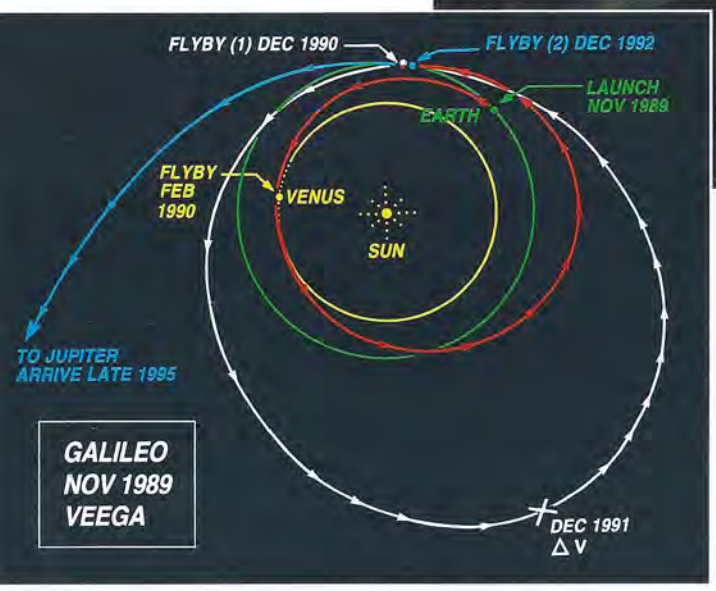
## Galileo/Centaur Mission

Before the *Challenger* disaster, the *Galileo* and *Ulysses* missions included the liquid-fueled *Centaur* upper stage. *Galileo*, in fact, was to be the maiden voyage of the rocket after it had been modified to work with the shuttle: a situation that made some of those involved quite nervous.

In the *Galileo/Ulysses* Final Safety Analysis Report (FSAR) three of the five dominant explosion types, and those that caused the most extreme conditions at the RTG location, involved a *Centaur* explosion.

According to the report, the most hazardous accidents would occur before the launch or after the shuttle is in orbit. For each phase of the launch, the report lists "most probable" and "worst case" calculations. In a prelaunch explosion, about 1,000 people could be exposed to doses up to twice the accepted occupational exposure level. The fatalities that result could range from 2 to 26.

The accidental explosion of the *Centaur* in the shuttle bay after reaching orbit would have a greater potential death toll.




***The cancellation of the Centaur upper stage forced Galileo mission designers to resort to a tortuous "gravity-assist" trajectory to reach Jupiter. To gain enough momentum, the spacecraft will swing by Venus once and Earth twice, making nearly three orbits through the solar system. (Here the first orbit is red, the second white and the third blue.) On the second pass by Earth, Galileo will come within 300 kilometers of the planet.***
***Chart: S.A. Smith***
***Painting: Michael Carroll***

Such an explosion could destroy the integrity of the RTG casing. If so, the plutonium fuel would be exposed during reentry and could quite possibly burn-up in the atmosphere. In this case, a very large population could be exposed to extremely low amounts of plutonium which translate to radioactive dose rates only a fraction of the naturally occurring background levels. The report puts the most probable death toll from such a case at 1,970 cancer deaths and the worst-case toll at 3,420 in the 50 years following. That would be in addition to a predicted 675 million cancer deaths worldwide over the same period.

In congressional testimony, NASA and DOE officials also said that plutonium could conceivably have been released in a *Challenger*-like accident. NASA chief engineer Milton Silveira has stated that a *Centaur* explosion could subject the RTGs to overpressures as high as 2,000 pounds per square inch (psi), uncomfortably close to the 2,200 psi that the units are designed to withstand.

Congressman Edward Markey (D-MA) demanded an absolute worst case estimate of the consequences of a *Challenger*-type accident with *Galileo/Centaur* on board. The answer he received was 386 deaths over a 50-year period and plutonium dispersed over 930 square kilometers of Florida.

"The *Centaur* was a veritable bomb," maintains Robin Sarbacher, a staff member of the House Energy, Conservation and Power subcommittee, at the time chaired by Markey.

On the other hand, Gary L. Bennett, project manager of DOE's special applications division, maintains that the best estimate of NASA and DOE experts is that the RTGs would have survived a *Challenger*-type accident intact.

"To get a plutonium release on a *Challenger* explosion you first have to buy the estimate of 2,000 psi overpressure," he explains. The 2,000 psi figure comes from an analysis of a test explosion called Project Pyro. In this test, pressure sensors were placed on the ground. As a result, they picked up both the direct pressure pulse from the explosion and a ground reflection. The effect was to substantially overestimate the explosion's overpressure, Bennett says.

For an airborne explosion like that of the shuttle, the overpressure should be reduced to 700 to 1,000 psi, a condition that the RTG casings should be able to survive, he maintains.

### RTG Test Program

Conclusions such as these are based on an extensive test program. According to Bennett, the government has spent between $20 and $30 million on RTG-safety testing. He argues that the "survivability" of these units has steadily improved as a result. However, he acknowledges that no specific modifications have been made to adapt the generators to the accident environments peculiar to the shuttle.

The testing has included exposing experimental hardware to such environments as aerodynamic heating, explosions, projectiles, impacts, propellant fires and water immersion. But it is a program that has had its share of difficulties.

In 1983, DOE researchers put together a lifelike test called "Project Direct Course." A mockup of an RTG was placed next to a kiloton of explosive detonated in White Sands, New Mexico. The unit was totally destroyed and only 70 percent of its original mass recovered.

According to Bennett, they went into the experiment without adequate analysis. They put the RTG only 36 feet from the explosives. As a result, the generator was demolished by fragments from the bomb casing. Two independent follow-up studies concluded that the test environment was considerably more severe than what would result from a shuttle explosion, he says.

Despite its flaws, Direct Course taught the scientists some important lessons. Arguably the most important was "that we had an environment we didn't know enough about: fragments. Since then we have done a large amount of testing," says James J. Lombardo, director of the special applications division of DOE.

Some might consider this a belated recognition of an important aspect of an explosive environment. However, sitting on the top of a conventional missile stack, the danger from frag-

ments is substantially less than it is with the shuttle design. For this reason, some analysts — Sierra's Weatherwax among them — feel that launching RTG payloads on conventional rockets is significantly safer than using the shuttle. Still, others in NASA disagree with this assessment and feel that the shuttle is safer.

## *Centaur* Cancellation

Since the *Challenger* accident, NASA itself has decided that the shuttle/*Centaur* combination represents too great a risk to astronauts while in orbit. As a result, *Galileo* and *Ulysses* have been forced to return to an earlier configuration using the Inertial Upper Stage (IUS).

"There's a false perception that we have a big risk problem here," objects John Casani, *Galileo* project manager at NASA's Jet Propulsion Laboratory. "The shuttle/*Centaur* would have been found good enough to launch and the shuttle/IUS is ten to a hundred times better."

*"The star that failed" is a phrase often used to describe Jupiter, the largest planet in our solar system. Like a star, it is primarily composed of hydrogen and helium. Galileo will be the first spacecraft to send a probe into the planet and sample it directly.*
*Image: JPL/NASA*

Safety studies for the revised mission are incomplete. Casani's assertion is based on some preliminary studies indicating that the conditions created when the shuttle's large, external tank explodes are not severe enough to detonate the solid propellant in the IUS. Without an explosion in the shuttle's cargo bay, the severity of conditions in the bay is radically reduced. According to a "quick look" study done by General Electric Company researchers for DOE, the amounts of radioactivity released in launch accident scenarios are a fraction of a percent of those calculated for the *Centaur*.

There is a potential trade-off for this increased safety margin, however. The IUS doesn't have enough total impulse power to boost *Galileo* directly to Jupiter. So mission planners have been forced to resort to some fancy navigation, called the VEEGA maneuver. VEEGA stands for "Venus Earth Earth Gravity Assist."

According to current plans, a shuttle will carry *Galileo* into orbit in 1989. After it is ejected from the shuttle bay, the IUS will thrust the spacecraft away from Earth. But it will head first toward Venus. By whipping around Venus, the spacecraft will pick up some of the velocity it needs to get to Jupiter. Ten months later *Galileo* will return to the vicinity of Earth, swinging around it at an altitude of 3,600 kilometers and picking up more speed. In another two years, *Galileo* will make its second and final loop around Earth. By passing within 300 kilometers or so the probe will pick up the final impetus it needs to reach Jupiter.

"We're worried now about the possibility of an accidental reentry on the second Earth pass," comments House staffer Sarbacher. The second Earth flyby is a matter of concern because the spacecraft will be traveling at an extremely high velocity relative to the planet. As a result, the aerodynamic heating that would result if the spacecraft plunged into the atmosphere would be considerably greater than that caused by a normal reentry.

"What does VEEGA mean? People are looking at that. There is a question whether or not the [RTG's] graphite shell will survive reentry. The guys are still cranking out numbers," says DOE's Bennett. Preliminary calculations suggest that the RTG would survive most of the possible reenty trajectories.

In past planetary missions, NASA has demonstrated the capability of accurately targeting spacecraft over billions of miles. Such past performance lends credence to Casani's contention that "We can target to within a couple of miles of our aim point. The probability of missing is one in a million."

If the RTGs cannot survive a VEEGA reentry, the health consequences would be equivalent to those calculated for the *Centaur* exploding in the shuttle bay during orbit.

## The Plutonium Question

In the final analysis, an individual's assessment of the risk of launching RTGs is heavily influenced by one's view of the hazard of plutonium.

The *Galileo* spacecraft will carry 22 kilograms and *Ulysses* 11 kilograms of plutonium, most of which is the isotope Pu-238. Pu-238 has a much shorter halflife and has a higher rate of radioactive decay than the more common isotope
Pu-239.

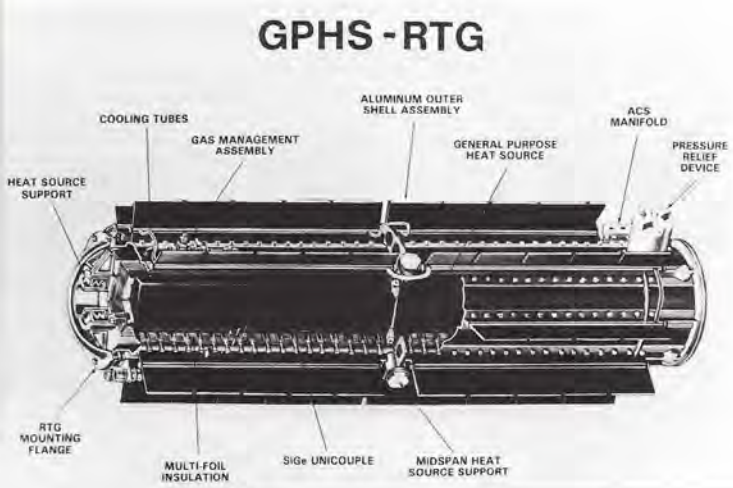
The standard unit for radioactivity is the curie. One curie is 37 billion radioactive disintegrations per second. Per gram, Pu-238 is 270 times more active than Pu-239. As a result, *Galileo*'s radioactive payload adds up to 274,000 curies of plutonium. That compares with a total of 360,000 curies of plutonium released to the atmosphere from nearly 18 years of above-ground nuclear testing which ended with the Limited Test Ban Treaty.

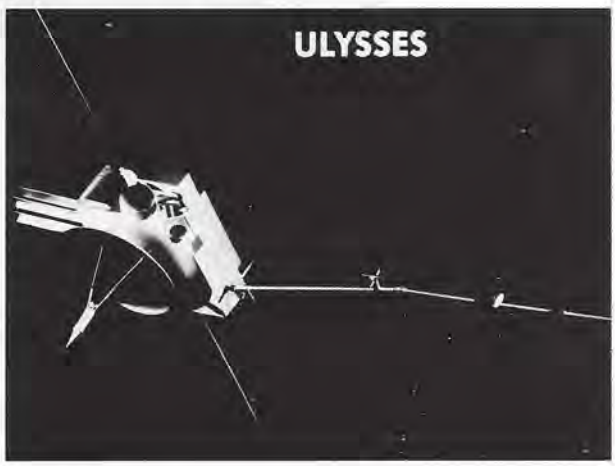
Named after Pluto, the god of the underworld, artificially created and radioactive, plutonium has acquired a special mystique. Its infamous reputation has been boosted by nuclear critics who consistently label it the most toxic material in the world, asserting that a single pound could cause lung cancer in every person on Earth. While technically correct, the critics fail to add that there is no credible way to achieve such a dire end with such a small amount of material accidentally. The only conceivable way to do so would be to implant microscopic plutonium particles in five billion pairs of lungs.

While there is general agreement that plutonium is highly poisonous, there has been sharp disagreement over just how great a risk it represents. Its toxicity is almost entirely due to its radioactivity. Like many naturally occurring radioactive elements — uranium, radium, radon, polonium — plutonium is an alpha emitter. Alpha particles are the heaviest of the three types of radiation emitted in natural radioactivity. Alpha radiation does not penetrate deeply: It can be stopped by a sheet of paper. But it is highly energetic and can do considerable damage to the living tissue that it strikes. Alpha emitters are powerful carcinogens. They are also suspected of causing birth defects, but much less is known about these effects.

Plutonium is most dangerous when inhaled. To reach the lungs, it must first be broken into small particles, less than 20 microns in size.

It has long been a matter of debate whether there is a threshold level below which living organisms can repair all the damage done by radiation. After all, there is a natural background level of radioactivity to which all living things are exposed. Unfortunately, if such a threshold exists it is too small for feasible experiments to detect. Instead, it is generally assumed that a given dose, administered at a very low rate over a long period of time, produces as much damage as if it were all administered rapidly. Estimates of cancer fatalities used in the *Galileo/Ulysses* safety analysis are based on the latter assumption.


***The Galileo (upper left) and Ulysses (right) spacecraft will carry RTG units (above) to provide power. GPHS-RTG is a General Purpose Heat Source RTG, ACS manifold is the active cooling system, SiGe unicouple is a chamber filled with a silicon germanium compound.***
***Illustrations: JPL/NASA***

Most experts consider this is a reasonably conservative approach. However, a vocal minority argue that the perniciousness of minute doses of plutonium has been seriously underestimated. The contention that plutonium is abnormally hazardous underlies estimates like those made by Dr. John Gofman, professor emeritus of the University of California, Berkeley. He has calculated that the plutonium in weapons fallout has caused over 900,000 cancer deaths.

While skeptical of the wisdom of launching RTGs, this prominent nuclear critic says that he has not calculated the possible consequences of an accident because he does not know the size of plutonium particles that would be created. "If all the plutonium was released in the respirable size range, then the consequences would be proportional to what I have estimated for fallout. On the other hand, if all the particles are greater than 20 microns they would have virtually no adverse effects," Gofman explains.

According to official estimates, the percentage of plutonium released in the respirable size range would vary from 0.1 to 5 percent, depending on the type of accident. Combining Gofman's methodology and the official particle size distribution produces an estimate of 700 to 34,000 cancer deaths that might result if all the plutonium in *Galileo* were released. That compares with a government worst-case estimate of 3,420.

Despite its critics' contention that plutonium is exceptionally carcinogenic "there is absolutely no evidence that it is any different from other alpha emitters," asserts Professor Marvin Goldman of the University of California, Davis who headed up the health effects portion of the *Galileo/Ulysses* safety study.

Still, another critic, Edward Martell of the National Center for Atmospheric Research, argues that the lack of substantive evidence of plutonium's extra hazard is the result of the government's refusal to support research that might force a tightening of radiation standards and so further damage the nuclear industry.

This controversy will not be settled for some time — if ever — because there is no way to distinguish cancers caused by minute amounts of plutonium from those caused by other carcinogens.

### Alternatives

NASA officials are clearly concerned that the political controversy over the hazard of launching RTGs might prove to be the straw that finally breaks the back of the long-delayed *Galileo* and *Ulysses* missions.

Jet Propulsion Laboratory engineers have explored the possibility of retrofitting the two spacecraft with solar panels. However, the problems involved made it impractical, says JPL's Ken Atkins.

For future missions, JPL engineers have looked at the possibility of using large solar arrays with light reflectors. To power a *Galileo*-like spacecraft at Jupiter, 200 square meters of photovoltaic cells would be required. "It's a nightmare to operate. And no one knows how solar cells will perform in such low temperatures and such low illumination levels," Atkins observes.

One of the lessons of *Challenger* is that the exploration of space remains a riskier venture than NASA officials have admitted. In the accident's aftermath the space agency is tightening its procedures in the attempt to reduce the odds of future shuttle accidents.

The post-*Challenger* decision to replace the *Centaur* upper stage with the IUS appears to have substantially reduced the likelihood of major plutonium releases in a shuttle launch accident. However, it has added another source of risk by forcing mission planners to slingshot the spacecraft around Earth to gain the velocity needed to perform outer solar system missions.

Even extreme estimates of the health effects of a plutonium release in such an accident translate into extremely small increases in the odds any individual will get cancer. Whether the American public continues to consider these risks worthwhile remains to be seen, and will be reflected, albeit imperfectly, in the political process.

Should the decision be made that the risks involved are too high, the US planetary exploration program would be seriously hobbled. RTG payloads might still be flown on expendable rockets, rather than in the shuttle. But, if this option is rejected as well, *Galileo* and *Ulysses* would be forced, once again, back to the drawing board. While most future inner system missions could use solar energy, there is currently no alternative source of power for probes to the outer planets, nor is there any assurance that such a source can be developed.

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*David F. Salisbury is a veteran science writer currently working for the University of California at Santa Barbara.*

# Exploring M

by Jacques Blamont

The Soviet Academy of Sciences is now planning the exploration of Mars in the 1990s, with a sample return to Earth targeted before the end of the century. They have discussed a three-phase program with France, which would follow a preliminary mission to the moon Phobos to be launched in 1988.

In the first phase, which could take place in 1992 or 1994, a satellite would be placed in orbit about Mars, and a package, possibly containing a balloon and penetrators, would be released on the surface. In the second phase, a rover, similar to the automatic *Lunakhods* that examined Earth's Moon in the 1960s and 70s, would be used to explore the terrain. The third phase would be returning samples of Mars to Earth.

During the same time, NASA has approved the *Mars Observer* mission, once scheduled for launch in 1990 but now delayed to 1992, and the agency is now studying options for its next steps. Many hope that NASA will commit to a Mars sample return mission, which could be organized as a joint effort of all the world's space agencies.

In the 1970s, all scenarios of Mars exploration were based on rovers — semi-clever vehicles that could move about on the surface, study its chemistry and physical structure, observe the landscape, and pick up and document samples. These rovers would require only minimal instruction from controllers on Earth. Their designers estimate the rovers' ranges in tens to hundreds of kilometers.

Today, concepts include legged locomotion similar to a spider's, or six-wheeled vehicles that are supposed to be easier to engineer. These contraptions would first have to land without damage, then traverse safely over varied terrain at least one kilometer per day for years, climb vertical steps or rock piles, cross crevasses of unknown width — and accomplish all feats without subjecting the science payload to unbearable shocks.

*In the late afternoon on Mars, the helium-hot air balloon combination floats four kilometers above the red plains. A camera package hangs from the open base of the hot-air balloon, while another instrument payload dangles 60 meters below.* *Paintings: Michael Carroll*

It is my contention that it is not easy to walk on the surface of Mars, but that it is easy to fly in the martian air.

A rover's motion across the surface would be seriously hindered by the ubiquitous boulders and stones, whose sizes vary between 10 and 100 centimeters. They surrounded the *Viking* landers, which landed in the smoothest regions that could be found. Faults, gulleys and cliffs abound. The pervasive dust also constitutes a danger: Wheels may become stuck in sand dunes; mechanical parts of an engine would become covered with fine dust.

In contrast, mobility can easily be achieved in the air. Balloons can be used as a systematic tool, not only to study the atmosphere but also to explore the surface and to collect rocks for sample return vehicles.

The atmospheric pressure at the surface of the Red Planet varies between 5 and 7 millibars, about 150 times smaller than ground pressure on Earth, where the value is about 1,000 millibars. Computation shows that a balloon of 5,000 to 10,000 cubic meters can carry a payload of 20 kilograms in the martian atmosphere. These figures can be extrapolated to a balloon of 100,000 cubic meters carrying a payload of 200 kilograms.

As we have seen in the January 1987 issue of *The Planetary Report*, during the Soviet *Vega* mission, small, superpressurized balloons were inflated in Venus' atmosphere and floated for 46 hours at an altitude of 55 kilometers and a pressure of 500 millibars. With minor modifications, the same system could be used for entry, release and inflation of balloons in the atmosphere of Mars.

## The First Step

Let us describe the first step, a double balloon which we hope to implement for a 1992 launch in the Soviet program.

To fly, a balloon needs buoyancy, which is provided by a light gas. Since no replenishment is possible, we have to imagine a system that flies without venting:

— A *closed* balloon of 3,000 cubic meters in volume contains helium or

# ans by Balloon

hydrogen delivered during inflation, which escapes only by diffusion through the skin.

— An *open* balloon, placed below the closed balloon, contains martian air heated by the Sun; it is a solar *montgolfiere* (hot air balloon). A very large opening at the bottom lets martian carbon dioxide (the primary atmospheric constituent) flow in and out. The solar balloon is effectively black to infrared radiation so that it traps heat. (This does not necessarily mean that the balloon looks black!)

A payload is attached to the balloon system at the end of a rope 100 meters long.

The quantity of helium is chosen so that during the night the balloon cannot fly, yet it has enough buoyancy to float while tethered by a guide rope, with the payload lying immobile on the ground. As measured by *Viking*, the martian winds blow at less than 4 meters per second over long periods. With a ground pressure of only 7 millibars, the wind's effect is negligible when the payload is on the ground. This would be the situation during the night.

When the Sun rises, the gas inside the "black" balloon heats up, and martian carbon dioxide penetrates and inflates the *montgolfiere*. When the temperature difference between the gas and the outside atmosphere reaches 50 degrees Celsius, the buoyancy is large enough for the system to take off. The ascension will be very slow, about one meter per second. This temperature difference will be reached very early in the morning.

At the temperate latitude of the *Viking* landers, the temperature difference will reach 100 degrees Celsius in the morning and the balloon will reach a ceiling around an altitude of 6 kilometers. At this level, both balloons would be practically full. It is essential at this moment during the flight to avoid venting the helium.

If a balloon has enough buoyancy to take off, it will ascend all the way to its ceiling. With a solar *montgolfiere*, the buoyancy will increase after take off because of the rising temperature of the gas. To avoid building up too much pressure in the helium balloon, the *montgolfiere's* buoyancy must be decreased before it reaches its ceiling. The easiest way is to automatically open a valve on top of the *montgolfiere* to vent some of the hot carbon dioxide.

Then the system will oscillate around an artificial ceiling during the day and could travel laterally over 500 kilometers. In the afternoon, it will descend to land at twilight. Part of the rope and the payload will lie on the ground and act as a guide rope. Both balloons will remain in the air, high above the surface.

The sequence will repeat the following day. A reasonable estimate of the diffusion rate of helium through the skin of the upper balloon indicates a lifetime of at least 10 days.

The reasons for using a double balloon are twofold: First, something has to keep the *montgolfiere* in the air overnight to avoid destructive contact with the ground and to insure inflation in the morning. Second, with a second balloon to add buoyancy, the *montgolfiere* can be smaller and so easier to inflate.

With the help of a valve which could be opened or closed by commands from Earth, the system could be used, not as a free balloon but as a ship, with the balloon acting as a sail and the guide rope as a keel. Two modes of operation can be imagined:

— The valve is closed. The balloon ascends a few kilometers and moves hundreds of kilometers per day under the action of the prevailing wind.

— The valve is kept partially open, reducing the buoyancy even during the day, to a value too small for the guide rope to leave the ground, but sufficient for the payload to rise. The balloon can even carry a deployable spinnaker and be able to navigate. We can imagine that, during the morning, the balloon will climb to its ceiling and determine the direction of the winds at all altitudes. Then it would adopt by itself the altitude where the wind blows in the →

*Sunset cools the air inside the open balloon, slowly deflating it and bringing the craft gently back to the surface. An instrument package lies on the ground, analyzing the martian soil. The morning Sun will again heat and inflate the balloon, and it will rise and move on to its next destination.*

desired direction. The system would then move toward a fixed objective, as aeronauts cleverly achieve in balloon races.

The payload for the first mission, with two balloons of about 3,000 cubic meters, would be between 17 and 20 kilograms, including 8 kilograms of scientific equipment.

### Relay to Earth

One major constraint of planetary exploration is the quantity of information having to be sent back to Earth. A single picture may contain 100,000 to 1,000,000 bits. The balloon cannot carry a large antenna, and the radiated power of its transmitter will be limited to a few watts. As a comparison, the Soviet craft landing on Phobos in 1989 will only be able to transmit one picture per day. A laser transmitter (which could transmit 50 kilobits per second from Mars to Earth) will not be available before the end of the century.

Therefore it is essential to use a martian satellite as a relay to Earth. An orbiter can support a satisfactory data flow from the gondola of 15 kilobits per second for many hours each day; an orbiter appears essential for retrieving all the data collected by the balloon, even if it would be interesting to receive balloon transmission directly to Earth, for Very Long Baseline Interferometry and wind determination.

Two such balloon systems should be deployed in 1993, as the French part of the Soviet mission.

We expect to obtain many pictures, both of the landscape and of the surface microstructure, a chemical analysis of material from several sites, magnetic and seismic measurements and, more important, a vertical sounding of the permafrost to a depth of a few hundred meters.

### Water Inventory

Establishing the water inventory below the martian surface is an essential step to understanding the history of the planet. We know that during Mars' first few billion years, catastrophic floods helped create the landscape we see today. This water has vanished: The polar caps are too small to be the reservoir, the atmosphere holds a very small amount of water vapor, and there are no rivers, no seas. Water can now subsist on Mars in only two regions: The regolith covering the surface could contain water molecules chemically linked to the minerals, and the first kilometer of the subsurface could contain ice similar to the permafrost found in Alaska, northern Canada and Siberia.

Finding these reservoirs would provide the information needed to retrace the chain of geological events. It is also necessary for planning the use of martian resources. Only a vehicle similar to a balloon can obtain this inventory. Electromagnetic sounding from an orbiter is impractical, and a rover with limited range cannot map permafrost around the globe.

We can envision different methods for detecting the permafrost; all of them measure the electrical conductivity of the soil. We can imagine radar sounding, which uses an electromagnetic pulse, or a martian analog of magnetotelluric techniques, which measure the voltage induced between two points by changing currents in Earth's ionosphere.

The operation in 1992-1993 is only a first step.

A mission with a reasonable number of balloons built on the preceding principles would provide a map of the permafrost, a map of the surface chemical composition, and many other parameters. Balloons appear therefore as powerful adjuncts to the survey of the planet by orbiters.

*Engineers at the Jet Propulsion Laboratory are already experimenting with double balloon concepts. The clear sack on top is filled with helium; warmed by the Sun, the black balloon below fills with hot air and rises. Photograph: Ed Hauptmann*

### Rover Aid

Another use of balloons is as an important part of a rover mission. Rovers are considered essentially as a way of providing mobility over perhaps 200 kilometers to enhance a sample return mission.

In a rover/sample return mission, balloons can add a global dimension. Suppose that a rover with balloon systems is placed in martian orbit. Then only the balloon lands and is deployed. The gondola carries a grab device to collect samples at each landing and document them with pictures and chemical analyses of the environment. Each sample would then be placed in a sealed box.

After many such landings and samplings — at least 10 — the balloon would be released and the collection of sample boxes would be left on the ground with a beacon. The balloon's ability to navigate with the guide rope can make sure the samples come from specific regions. The rover would then land near the beacon. It could make a detailed analysis of samples inside its radius of action, and also retrieve the balloon's samples that came from very distant points.

A primary benefit of this scenario is that it would provide access to ground material from the poles. In the polar regions lie stratified layers of dust and ice, which are probably produced by climatic cycles: When the weather is warm, dust carried by the wind from all over the planet accumulates in the caps; when the weather is cold, ice forms above the dust. A drill could sample vertically through these strata and provide direct measurements of the climatic changes.

Many believe these changes are induced by periodic variations in the orbital parameters of Mars, including the duration of the successive episodes. (See the January/February 1985 *Planetary Report*.) Since some scientists offer the same explanation for the ice ages on Earth, the implications of understanding the martian climate are obvious. Perhaps no rover can ever roam on the caps of Mars, but balloons can fly over and land on them.

And now let our imaginations visit the future. Airplanes can fly in Mars' atmosphere, as shown in a 1977 study by people at the Jet Propulsion Laboratory. Dirigibles using hydrogen manufactured on Mars could join them in the skies. In the far future, all of our aeronautical skills, hard-won in Earth's atmosphere, may find application in the alien skies of Mars.

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*Jacques Blamont conceived of the balloon experiment that* Vegas 1 *and* 2 *dropped off at Venus on their way to Halley's Comet. He is a scientific consultant to the Centre National d'Etudes Spatiales in Paris, France, and an advisor to The Planetary Society.*

# World Watch

**by Louis D. Friedman**

HOUSTON — In an upbeat discussion of the future of planetary exploration, Lew Allen, Director of the Jet Propulsion Laboratory (JPL), Aaron Cohen, Director of the Johnson Space Center (JSC), and Geoffrey Briggs, Director of the Solar System Exploration Division of NASA, revealed new plans for United States exploration of Mars. JPL and JSC are undertaking a joint study of a Mars Sample Return Mission, and will consider the use of rovers and requirements for precursor missions.

Their discussion demonstrated how far NASA has come in the two years since The Planetary Society began to promote Mars exploration. Our efforts took off in July 1985 at the "Steps to Mars" conference in Washington, DC (see the January/February 1986 *Planetary Report*). There we presented the case for Mars to a somewhat skeptical group of government officials. Now the space agency leadership seems to be firmly behind the Mars program, and they are working to develop the capability to launch a sample return mission in 1996 or 1998.

The JPL-JSC study will examine the requirements for sample return missions, including vehicle concepts, aerocapture braking into Mars orbit, rendezvous in Mars orbit, site selection, sample collection and return to Earth. A rover's mobility and ability to pick up samples are particularly important areas to be studied. The space centers will also investigate precursor missions, which could include orbiters, balloons and landers, to see what is necessary before undertaking a sample return mission.

HOUSTON — In a special session organized by The Planetary Society at this year's Lunar and Planetary Science Conference, Soviet scientists told an audience of American and European colleagues about their plans for a 1992 mission to Mars. The scope of the mission stunned the audience.

The Soviets are considering a large remote-sensing orbiter, instrument-carrying balloons, surface-penetrating instruments, and perhaps even a rover. Traveling on a nearly polar, elliptical path, the orbiter will carry an optical and radar complex, perhaps including synthetic aperture radar to image the surface, or a few centimeters below it. The resolution (ability to discern detail) of the optical imaging system could be as fine as 10 meters.

This Soviet mission will prepare the way for a sample return launched in 1996 or 1998. The mission would therefore concentrate on characterizing and selecting possible landing sites, mapping the surface and analyzing the environment.

In a notable difference from the NASA discussion of Mars exploration, the Soviet scientists explicitly proposed that the sample return mission be an international effort. Valeriy Barsukov, Director of the Vernadsky Institute of Geochemistry and Analytical Chemistry, noted that the French are already participating in the 1988 *(Phobos)* and 1992 Mars missions, and that the European Space Agency has shown interest in their program. "It would be a shame if the Americans didn't join the sample return effort," Barsukov said.

Soviet negotiators had proposed a cooperative rover/sample return mission in the preparation of the draft agreement on US/USSR cooperation in space, but the US rejected it, for the time being, since the US government has no such mission plan.

Academician Barsukov also described plans for a 1994 or 1996 Mars lander that would carry robot "moles" able to dig 20 to 30 meters below the surface.

WASHINGTON, DC — NASA is now studying a "bold new initiative" for its future. Heeding calls for an agency-wide goal, NASA Administrator James C. Fletcher delegated astronaut and Planetary Society Advisor Sally Ride to prepare a special study to find a goal that NASA can strive toward in the 1990s and beyond. The team assembled by Dr. Ride has developed four candidates:

1) Mission to Planet Earth — to examine our home planet from space, and study change from a global perspective.
2) Planetary Exploration — to reinvigorate the program of sending robotic probes to study Mars and the outer planets.
3) Return to the Moon — to set up a permanent base for human activities on the Moon.
4) Human Exploration of Mars — to send a human mission to the Red Planet.

The chosen goal will make a minor difference to the overall US space program, which is still envisioned as broad and balanced. But the decisions about technology and missions that set the pace of exploration will be influenced by whatever goal is chosen. More significant, a goal is needed to gather and to harness public support.

Meanwhile, the NASA Advisory Council has recommended to the agency's Administrator that the US "identify, as its primary goal, exploring and prospecting on Mars."

MOSCOW — US Secretary of State George P. Shultz and Soviet Foreign Minister Eduard A. Shevardnadze have signed an accord on cooperation in space. Details of the agreement had been worked out last November (see the January/February 1987 *Planetary Report*). The Planetary Society has long advocated such an agreement, beginning with our 1985 "Steps to Mars" conference.

Ironically, the accord was signed on the same day that NASA directed JPL to delay the *Mars Observer* from 1990 to 1992 (see pages 12-13). The agreement cites *Mars Observer* and future Mars missions as principal areas for US-USSR cooperation.

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*Louis Friedman is the Executive Director of The Planetary Society.*

## Mars Underground News Now Available to Society Members

*The* Mars Underground News *is now available to Planetary Society members. "The Mars Underground is a closely knit but loosely woven network of people representing government, private industry and individuals. It has one major goal: landing humans on the Red Planet, Mars," according to Leonard David, editor of the newsletter and a founder of the Mars Underground.*

*The* Mars Underground News *will provide "a communications channel for scientists and others interested in the exploration and eventual settlement of Mars. Our objective is to report individual projects, programs, trends, political activities and speculative opinion regarding the broadening of humanity's reach to the fourth planet from the Sun," David said. The newsletter will be published at least four times per year.*

*Believing that this newsletter will help coalesce support for and study of human exploration of Mars, The Planetary Society has agreed to pick up the publication costs. The money will come from the member-supported Mars Site Survey Fund.*

*Planetary Society members who would like to keep up with the latest-breaking news about Mars exploration can now receive the* Mars Underground News. *Subscriptions are $10.00 per year. If you would like to subscribe, send your check to:* Mars Underground News, *The Planetary Society, 65 N. Catalina Avenue, Pasadena, CA 91106.*

# SOCIETY Notes

## The Mars Observer Campaign by Louis D. Friedman

Unlike many other public interest organizations, The Planetary Society has preferred to bypass temporary political and short-term policy issues and focus on the long-range positive aspects of space exploration. Only once in our first years did we ask our members to take action on a political issue. That was an effort to urge the new Reagan administration to launch a US mission to Halley's Comet.

Of course, we have taken up many planetary exploration issues. The Society has: supported increases in the research and data analysis budget in space science; urged the retargeting of *Galileo* to encounter an asteroid; promoted the recommendations of the Solar System Exploration Committee and the National Commission on Space; published special issues of *The Planetary Report* on Mars, Titan, human flight, and other targets of interest; held conferences in Washington on major issues; given testimony to Congress and briefed other government officials. But, only with the Halley mission did we go to our members and try to rally their support against a NASA decision.

All this changed during the last week of August 1986. At NASA, inside the Office of Space Sciences where they were wrestling with their 1988 submission to the Office of Management and Budget (OMB), the staff decided to cut money from the existing *Mars Observer* to fund three new starts: a solar telescope ($12 million), a global geosciences program ($25 million) and a "vitality package" for university science research. They also increased development work on an advanced x-ray satellite ($25 million). The $50 million cut to *Mars Observer* would delay the mission launch from 1990 to 1992.

Knowing that once that proposal went to OMB there would be little chance of getting the money back, the officers of The Planetary Society quickly authorized a strong protest. In our minds, the *Mars Observer* delay was outrageous. The fight to keep it on schedule embodies many of the reasons for which the Society exists: to support exploration of the planets, to increase public interest in Mars, to urge international cooperation in planetary science and to help get the US back on track in space exploration.

In the first two weeks of September, we visited and wrote government officials in the White House, Congress, the OMB and NASA. We sent a telegram to every contributor to the Society's Mars Fund, asking them to write the Senate and House Appropriations Committees. These committees must approve any changes to NASA's operating plan — and NASA was planning to change the fiscal year 1987 plan (which began October 1, 1986) to cut the *Mars Observer* immediately.

The concerted action had an effect. NASA Associate Administrator for Space Science, Dr. Burt Edelson, and Administrator, Dr. James Fletcher, both indicated privately and publicly that no budget cut would be made or planned for *Mars Observer*. Dr. Fletcher stated, "We have decided . . . to continue work on the *Mars Observer* on schedule to provide launch readiness for the 1990 opportunity." Dr. Edelson told *The Planetary Report*, "We have reconsidered the proposed delay and are now still working on the planned 1990 launch for *Mars Observer*." We understood this to mean that the OMB budget proposal would have *Mars Observer* on schedule. In fact, it did not.

In late October 1986, NASA announced the "manifest" — its shuttle launch schedule for 1988-1990. On it were identified three planetary launch slots for four missions: *Galileo*, *Ulysses*, *Magellan* and the *Mars Observer*. They said a review in late January would decide which of the four

***Planetary Society members wrote many thoughtful and persuasive letters to members of Congress and NASA Administrator James C. Fletcher in support of the 1990 launch of the Mars Observer. We'd like to share selections from those letters with you.***

### TO DR. JAMES C. FLETCHER

*We have not had a single exploratory space flight since the launch of the* Pioneer *Venus mission in 1978. We cannot maintain our position in space if we continue to stagnate like this. Delaying the* Mars Observer *is just one more step to total stagnation in space on our part.*

*History teaches us that those who fail to reach for the future are doomed to exist in the past. We are fast becoming a nation that lives only for the present, does not think of the future and has forgotten the past.*
DAVID LOCKIN, *California*

### TO SENATOR ROBERT STAFFORD

*I am aware that NASA has its share of tough decisions to make, but it is also true that its current decision makers are completely misjudging the extreme political as well as technical importance of this particular mission. The US has fallen very far behind in the pace of our efforts in the exploration of space, and in the preparations for the future use of the absolutely priceless resources which will be there only for those with the vision and staying power to get to them.*

*This mission does not depend on an available shuttle launch slot. It can go aboard an available* Titan 3 *booster and the money can be found in the current NASA budget. It's just a matter of choices, and in this particular case, NASA is choosing dead wrong. Please tell them so!*
MEL HUNTER, *Vermont*

### TO DR. JAMES C. FLETCHER

*What concerns me most is a subtle, though powerful and malignant attitude that may be evolving amongst our youth. Our children will have another setback in space. They were short-changed in the exploration of Comet Halley; there were several rocket failures after the shuttle tragedy; and the tragic decisions to launch the space shuttle and the horror of the explosion itself I believe are contributing an opposing effect to the confidence, integrity, commitment, consistency and faith in our space program and its leaders. Our children (and adults) need effective models and now a symbol of the strength of our country — our space program — is poised for another major setback.*
DAVID A. HARBSTER, *Arizona*

### TO CONGRESSMAN LEON E. PANETTA

*Should the* Mars Observer *mission, already approved by Congress, not launch in 1990 because of this recent NASA decision, America will miss an important scientific opportunity and will forfeit our chance to share in subsequent discoveries with fledgling space partners. And this loss will actually cost $100*

would be fit into the slots. In December, however, we learned that NASA had already decided: The OMB budget submission had the *Mars Observer* on the 1992 schedule, and a letter to the Congressional Appropriations Committees was in preparation saying the budget "reflects a delay in the launch of the *Mars Observer* mission." It is this letter, released on January 2, 1987, which we quoted in our all-member, urgent mailing in January.

Although NASA had been studying the use of expendable launch vehicles for at least six months, and had been advised by almost all relevant committees and agencies to use them for space science missions, they stated in January that no decision has been made about the use of expendable launch vehicles for any of the planetary missions. In particular, a *Titan 3* was obtainable, without *any* fiscal year 1987 funds required. Nonetheless, Dr. Fletcher stated in the January 2 letter, "expendable launch vehicles have been considered, but were not recommended in the fiscal year 1988 budget because of the uncertainties with regard to the availability of vehicle and early-year funding requirements."

We responded to this situation with our mailing to members. It was an extraordinary decision for the Society's Board of Directors — committing to a short-term campaign on a near-term issue. Timing was crucial — NASA had made clear its intention to kill the 1990 launch possibility by the end of January. Only congressional action could stop them — and Congress was a little preoccupied in the first week of its new organization and the President's State of the Union Address. The mailing went out January 23. By January 28 we were hearing from congressmen about our members' response.

In addition to letter writing, the Society has made its presence felt on this issue in several other ways. The officers visited many senior NASA officials, members of Congress and of the administration. We supplied information to the news media, and held a very well-attended press conference on Capitol Hill. At a hearing of the Senate Commerce, Science and Transportation Committee, Dr. Sagan testified for the Society. He cited (and brought a large box of samples of) the enormous membership interest in the *Mars Observer* mission as expressed by the letters.

While we anticipated a strong reaction from our members, we were surprised by the campaign's effect in Congress. Based on the many congressional inquiries — to NASA, to the space committee staffs in Congress, to the Library of Congress Congressional Research Service and to us — we believe it is fair to conclude that Mars is a goal that can galvanize support for space exploration. Even though we were criticizing *their* proposed delay and deluged them with many thousands of letters, for the most part NASA welcomed the outpouring of support for one of their programs and for US missions to Mars.

Then, on March 13, NASA issued a press release confirming that the 1988 budget put the *Mars Observer* on a schedule for a 1992 launch. The press release was only three sentences long, and apparently had been watered down following a storm of protest led by The Planetary Society, private industry and the scientific community. The original wording reportedly had called the delay "irrevocable."

The space agency cited its inability to obtain a *Titan* launch vehicle, as well as budgetary pressures, as the reasons for delaying the mission two years. However, both the US Air Force and Martin Marietta Corporation, builder of the *Titan*, said that a vehicle was available, and indications are that Congress may offer to put up the necessary funds. The efforts of Planetary Society members have built up an enormous base of support for the *Mars Observer*.

On the day we delivered our March/April issue to the printer, we learned that NASA was about to announce its "irrevocable delay" to the mission. The magazine had included a letter to Society members from Dr. Fletcher indicating his support of the mission, his appreciation of Society members for their support, and his hope for finding a *Titan* launch vehicle. Clearly the magazine couldn't go out as it was, so we delayed it to remove Dr. Fletcher's letter.

But on April 15, NASA directed JPL to stop working toward a 1990 launch. In turn, JPL had to stop work on the RCA contract to build the spacecraft. As their reason for taking action before Congress could consider the mission, NASA cited inadequate funds. In a press release that same day, The Planetary Society took strong issue with that reason.

We are trying to convince Congress to restore the 1990 launch.

### LAST CALL FOR HAWAII

Time is running out to sign up for The Planetary Society's Hawaii Conference in August. Space is limited for lodging and airline discount rates, so make your reservations now. To receive information, send your name and address to "Hawaii," The Planetary Society, 65 N. Catalina Avenue, Pasadena, CA 91106.

### CASE FOR MARS

*July 18-22* — Case for Mars III: Strategies for Exploration. Sessions for the public and educators on Saturday, July 18, Boulder, Colorado.

For event updates, call our information lines: 818/793-4294 from west of the Mississippi; 818/793-4328 from east of the Mississippi.

*million more! Less, for more money! This is not how taxpayers expect our money to be spent.*
JAMES M. BRICKEN, *California*

### TO DR. JAMES C. FLETCHER

*I believe that the survival and future of the human race depends on the exploration and cooperative utilization of the resources of space. The exploration of Mars is the first step in planetary exploration. If the United States keeps its head buried in the sands of bureaucratic complacency we will find ourselves applying to the Soviets and Japanese for visas to the planets and stars.*

*What is really frightening to me is that NASA seems to be getting derailed from the purpose for which the American people put it on the tracks. Instead of reaching out to the stars we seem to be reaching out to find better ways to destroy ourselves.*
CHARLES B. HUMPHREY, *Kansas*

### TO CONGRESSMAN RICHARD A. GEPHARDT

*As an American it hurts me to see the Soviets advance toward Mars while the United States' space program seems to be grounded. Since the* Mars Observer *is the only US mission approved for Mars, the results obtained from this mission would be the only data the US could contribute toward the US/Soviet Bilateral Agreement on Space Cooperation. Thus the credibility of the United States as a potential partner in space exploration will be damaged. Possible partners would be the Europeans, the Japanese and the Soviets.*

*I know you remember as well as I do how proud we felt being American when the United States set foot on the Moon. Let's bring back the feeling by not delaying the* Mars Observer *launch.*
MICHAEL P. CONNER, *Missouri*

### TO CONGRESSMAN MICKEY EDWARDS

*We were dismayed to learn that the* Mars Observer *mission is being delayed. With the Soviet Union launching spacecraft to Mars in 1988 and planning another mission in 1992, it seems strange that we would not launch our mission.*

*President Reagan has renewed our patriotism, but he seems to be creating a notion that we can rest on our laurels and take pride in that attitude. He has forgotten that our laurels were earned by hard work, sacrifice and daring to do what others have only dreamed of.*
GARY L. AND BARBARA L. KING, Oklahoma

### TO DR. JAMES C. FLETCHER

*I am appalled to hear that the* Mars Observer *program is faced with a delay, and although I am well aware of the terrible problems faced by the present launch vehicle situation, I do hope it will go ahead as it is one of the most important of all planetary programs.*

*Meanwhile, I wish you the best of luck in your present demanding position.*
ARTHUR C. CLARKE, *Sri Lanka*

# News & Reviews

*by Clark R. Chapman*

One of the joys of astronomy and space exploration is its orientation toward the future. It is difficult to conceive of space exploration without having an optimistic view about humankind's potential for solving (or at least containing) the present threats to our existence. Space travel is a technologically complex endeavor, involving the successful integration of the activities of many human beings. It is a special reward, therefore, to watch the budding interest in astronomy by those who will live into the middle of the 21st century. Today's children may witness or even participate in the realization of some of our science fiction dreams about exploring the solar system and the cosmos.

When I was young, I learned about the stars from children's books available in my local library. I also dabbled in *Sky and Telescope* and in *Spaceflight* (published by the British Interplanetary Society), but they were written for adults. Today's kids have a monthly space magazine of their own: *Odyssey*.

*Odyssey* is published by the same folk who put out *Astronomy*. This thin, almost ad-free monthly publication is geared toward kids aged 8 to 14. Obviously, the publishers hope they will eventually graduate to *Astronomy*. And in some ways, *Odyssey* is just a smaller and simpler version of *Astronomy* itself. It has its own starmap-of-the-month, space news column and letters column. The May issue has a couple of feature articles and a futuristic story about work on a Moon base when *Odyssey*'s readers will be turning 50. And there's the usual array of space art and telescopic photos of the heavens.

Befitting its focus on the younger generation, however, *Odyssey* interacts with its readership more than *Astronomy* does. The magazine runs poems, puzzles, letters and art contributed by its readers. There are contests and readers' forums. The magazine is replete with pronounciation guides (but less frequently, helpful definitions) for complex technical words. And there's an attempt to involve the readers with hands-on astronomy projects.

Readers are warned to "ask Mom or Dad" before taping to a home wall some cut out models of Earth, Moon, Pluto and Charon. The article on "double planets" tries to get across a few simple concepts of interplanetary distances and size relationships. I don't know how many young readers will actually apply scissors and rubber cement to *Odyssey*'s centerfold, but many will certainly come to appreciate how far away our Moon is and how Pluto-Charon are really a "double planet." On the down side, the article rarely escapes from numerology and metrology, which can wear thin, to consider such fascinating, current problems as "what is Pluto made of?" Also, the author missed a bet by failing to describe a way of arranging the cut outs on the wall to illustrate the remarkable Pluto-Charon eclipse/occultation phenomenon now underway for a few short years. And — perhaps through carelessness — there is an inaccurate sentence about apogee and perigee.

Especially delightful is David Levy's little article on how to make friends with the constellation Hercules. But more than anything, I enjoyed reading some of the readers' letters. It is ironic and depressing that, for these kids, human exploration of the Moon is as far back in their personal prehistory as the Great Depression is for post-war baby-boomers. Speculations about Moon bases must not be quite the same for these kids as they were for kids growing up in the 1960s, when the US space program seemed to be heading straight for the stars.

Yet, many of *Odyssey*'s kids are optimistic that sooner-or-later we will have bases on planets from Mercury to Pluto, and people around the solar system will be living in peaceful harmony. Fear of pollution and nuclear war in the near term pervades the thoughts of many young readers, but all seem to find potential salvation in space. I'm looking forward to the August issue, when *Odyssey* readers will be addressing the question of "If you were president, what goal would you set for the US space program today?" I hope James Fletcher and Ronald Reagan will be paying attention, too.

### *Celestial Cataclysm*

The big story in *Odyssey*'s May issue, of course, is the supernova. It is indeed a special time to be alive during the first nearby supernova since the invention of the telescope in the early 1600s. Practically every space-related magazine — and many others as well (such as *Time*'s cover story for March 23rd) — have been highlighting this remarkable event.

Supernovae are the most spectacular time-variable phenomena we can witness in the heavens. For a few months, a single star outshines its entire galaxy in the cataclysmic agony of its death. Many theorists have thought that supernovae explosions are intimately related to the processes that create new stars and solar systems. And the heavy elements they spew into space are woven into the fabric of life itself. It is regrettable that this particular star chose to burst on the scene near the south celestial pole, so it is below the horizon for most of the world's population. But for scientists, the event is a bonanza of the first order. Some predictions have already been confirmed, but in other ways supernova 1987A is doing its own thing.

I don't expect to see much more about the supernova in *Time* magazine. Its appearance on *Time*'s cover was more ephemeral than the star's own brief appearance in the skies. But other magazines I review in this column, including *Science News*, *Science*, *Sky and Telescope*, *Astronomy* and (for the kids) *Odyssey* will certainly be providing us with weekly or monthly accounts. By year's end, however, I expect there will be a sense that we have been surfeited with supernova news. Halley hype finally came to an end with final "comet special issues" in magazines like *Sky and Telescope* (March issue) and even your favorite *Planetary Report* (the last issue). Yet, just as some of the most important research on Halley's Comet is continuing (astronomers are observing it as it recedes beyond Jupiter's orbit, and doing in-depth analysis of the wealth of data gleaned over the past couple years), the supernova will be a continuing topic of intense interest to astrophysicists for years to come. And you will hear more about it here, too, from time to time.

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*Clark R. Chapman lives and works in Tucson, Arizona.*

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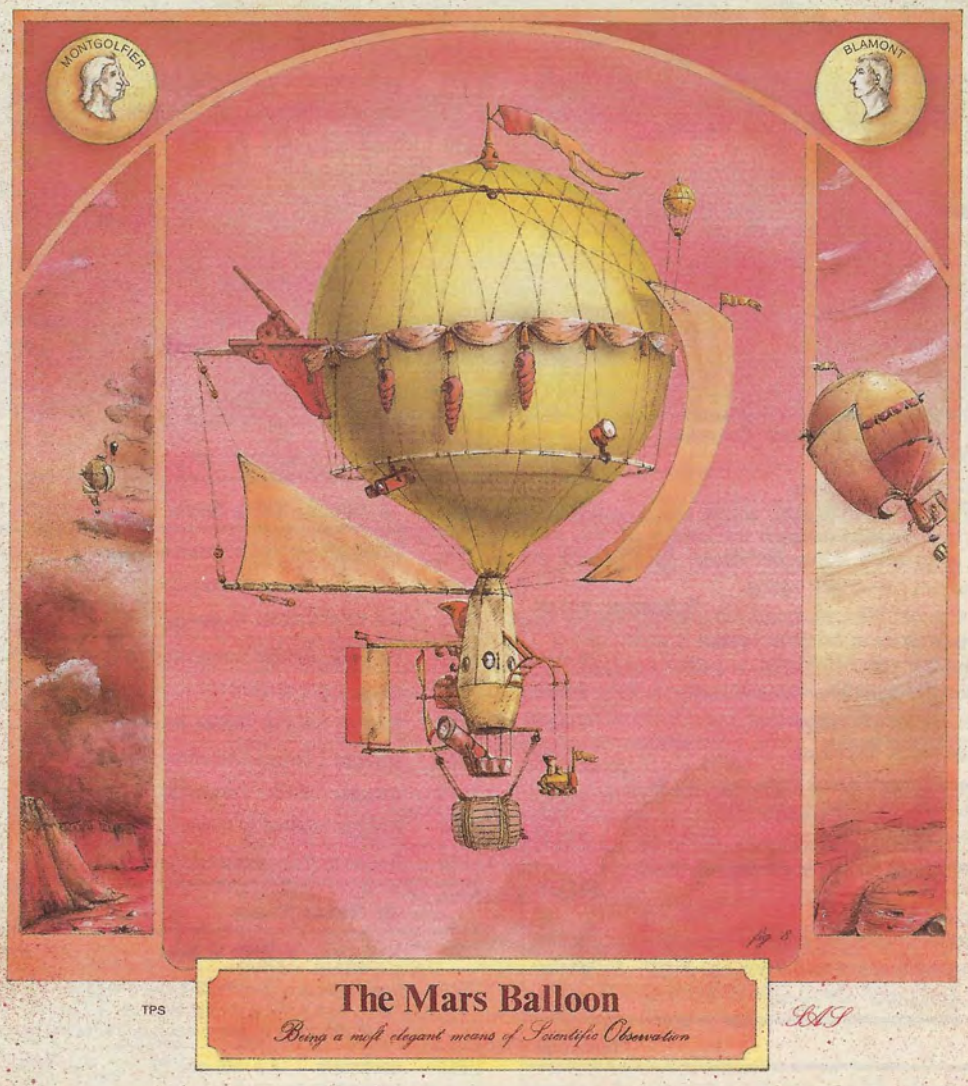


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***S. A. Smith is an artist and illustrator who frequently contributes to The Planetary Report. He lives in Altadena, California.***

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