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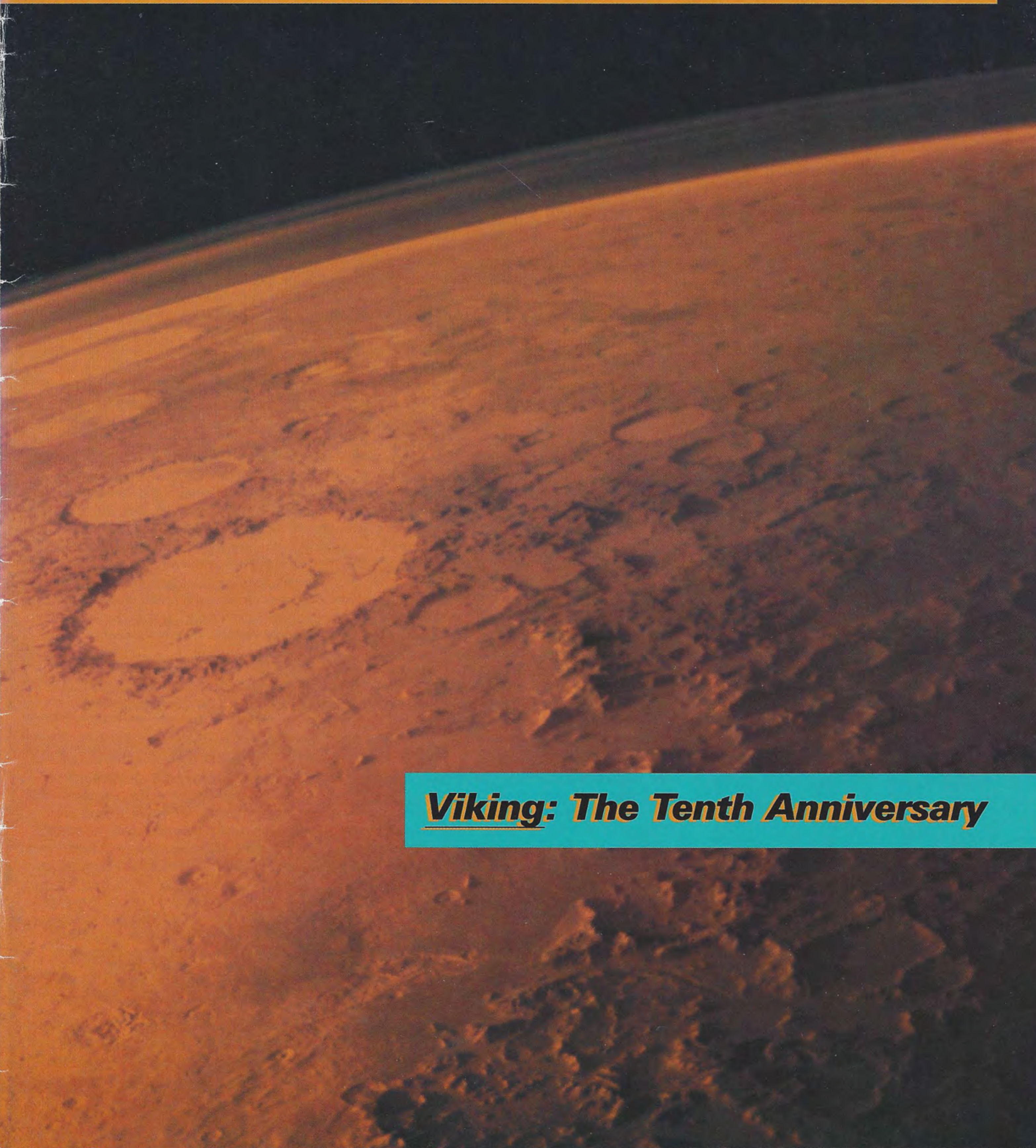

Viking: The Tenth Anniversary

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COVER: Ten years ago Viking 1 reached Mars, and the doughty little spacecraft began to turn the mysterious Red Planet into a familiar place to scientists and television viewers back on Earth. Here, the spacecraft looks across the cratered surface to the cloud-streaked horizon. Argyre Planitia, the large, smooth basin in the lower left, is probably the remnant of an asteroid impact. **Image: JPL/NASA**

Letters to the Editor

I and a number of others in the United Kingdom are of the opinion that we need to raise interest in the possibility of launching a Pluto mission. The last of the most favorable opportunities to visit Pluto in more than two hundred years occurs in 1989. Clearly the best solution would be for a probe configuration using any remaining *Voyager* backup parts, as the available time to mount the mission is very short.

Recent advances in our knowledge of this "Last Outpost" of our solar system suggest that it may be one of the most important keys to unlock the secrets of the origin of the Sun and planets, and hence of other planetary systems. I suggest that urgent steps should be taken to mount a space mission to the only as yet unvisited (after *Voyager 2* reaches Neptune in 1989) major planet.

RICHARD L. S. TAYLOR, *University of London*

I have been a member of The Planetary Society for five years and wholeheartedly support its aims. There is one matter, however, about which I am concerned. This is the resentful attitude that some space scientists have toward one facet of space exploration: manned spaceflight. To me, having the human race move out into our home, the solar system, is a natural step in evolution.

Obviously, there are some cases where it makes much more sense to send machines and not humans, but there are also situations in which a combination of humans and machines is needed. If we are to be able to continue exploring our home, we are going to have to be able to assemble spacecraft in orbit where they do not have to withstand the rigors of launch before being sent on their way. Future SETI programs may require antennae to be built on the far side of the Moon. Space has much to offer: knowledge, beauty, inspiration, energy, resources and — perhaps the greatest thing of all — peace through international cooperation. We need manned space missions to gain the full benefits.

Following the tragic loss of *Challenger* and her crew, I hope that other members of The Planetary Society will join me in my resolve to try even harder to make as many people as possible appreciate the necessity for peaceful space exploration, both manned and unmanned, so that we humans may have a hopeful future.

JANE L. BROOKS, *Millswood, Australia*

I received today a solicitation for membership in The Planetary Society. But for the tragic destruction of the space shuttle *Challenger* and her crew, the invitation would have ended up in the trash basket.

In the wake of the accident, however, some voices are already calling for the reduction or elimination of funding for the shuttle and other space programs. I care little about the economic and political consequences of such suggestions, but I care a great deal about the philosophical implications. I do not believe that man can afford to abandon his individual or collective searches for knowledge without becoming the lesser for it.

I have consequently accepted membership in the Society. I urge you to continue to lobby Congress for the funding of US space programs. In a spirit of fiscal responsibility, I would also urge you to continue to push for jointly funded and conducted space missions with other national and multinational space agencies. I see no good reason that space exploration should not be cooperative.

WALTER BORGES, *Dallas, Texas*

ERRATA: On page 13 of the March/April 1986 Planetary Report, *the middle frequency on the META (Megachannel Extraterrestrial Assay) chart should read 3000 MHz, not 300 MHz. On page 8 of the May/June 1986 issue, the image in the bottom left should be credited to the Max Planck Institut für Aeronomie.*

Mars: Realizing The Dream

The dream that emissaries from Earth would one day explore and eventually inhabit Mars has been with us at least since the late 19th century — when the habitability of the planet was first seriously debated. In the last two or three years this prospect has received unprecedented attention. In the United States, at a time when NASA was specifically enjoined against even contemplating such missions, a small group, largely of graduate students, called the Mars Underground and supported by The Planetary Society, organized a set of research projects and scientific meetings on the subject. They helped keep the dream alive. A design study commissioned by the Society suggested that advances in space technology have made such missions surprisingly accessible. At a meeting at the National Academy of Sciences, cosponsored by the Society and the American Institute of Aeronautics and Astronautics, a remarkable unanimity emerged among American, Western European and Soviet delegates: The exploration of Mars by humans is feasible and, for a very broad and ecumenical range of reasons, desirable. Some would even argue that it is urgent.

The pace is now quickening. The President's National Commission on Space has underscored manned (and womanned) exploration of Mars as a key goal for the future of the US space program, and it is clear that such a goal would go far to bring order and a fixity of purpose to a beleaguered NASA. Editorials in many newspapers, including five so far this year in *The New York Times*, have advocated a joint US/USSR Mars program with human crews, and a US Senator, Spark Matsunaga, has just published a book on the same theme. In commemoration of the tenth anniversary of the historic *Viking* missions to Mars, NASA is sponsoring a major international meeting in Washington on future Mars exploration. A range of more detailed engineering studies on human missions to Mars and their robotic precursors is now underway in the United States and the Soviet Union. And five unmanned spacecraft — four Soviet and one American — are scheduled to arrive in the Mars system in the 1988-1992 timeframe.

Many aspects of the question are aired in this issue of *The Planetary Report*, including two accounts of the first unmanned landing on Mars by *Viking* in 1976, justifications for human voyages to Mars, policy implications, and alternative future mission profiles.

Further developments in this fast-breaking subject can be expected in the near future and will be reported in these pages. The Planetary Society hopes to continue spearheading a number of these efforts. It is still too soon to be sure, and many difficult steps remain to be taken, but there now seems to be a real chance that the dream of Mars will be realized in our lifetimes. — *Carl Sagan*

Envoys of Mankind

In the 1967 Outer Space Treaty, the United States and the Soviet Union pledge not to introduce nuclear or other weapons of mass destruction in Earth orbit or on any other celestial body. The treaty prohibits military bases or weapons testing of any sort on the Moon and planets. The nations are to "facilitate and encourage international cooperation" in the scientific exploration of the Moon and planets and "shall regard astronauts as envoys of mankind." Joint activities on other planets are explicitly encouraged by Article 1 of the treaty, which reads in its entirety: "The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind." — CS

NASA, the Presidency and International Leadership

by Bruce C. Murray

Dawn creeps across the Tharsis region on Mars, revealing a plume of water-ice clouds trailing out from the volcano Ascraeus Mons (upper center). Early morning frost covers the large impact basin Argyre Planitia (bottom). The atmosphere, clouds, frost and sunlight remind us that Mars is not so different from Earth. Indeed, it is a world waiting to be explored by humans. Image: JPL/NASA

As the Rogers commission delivers its report, the United States ponders the verdict on the *Challenger* disaster and wonders what lies ahead for American manned space flight.

But what NASA needs now, even more than new rocket boosters or any other machinery, are clear goals set by the president. Twenty-five years ago, President Kennedy committed the United States to placing an American on the Moon by 1970. That *Apollo* commitment enabled a golden age of American space exploration by humans and robots. Without a similarly clear and compelling destination for Americans in space, the annual congressional budget process and the brokering among special interests will lead to a diffused, diminished and mediocre outcome for all civilian space activities. American dreams and hopes, symbolized by space exploration, are more at risk now than ever before.

What should be the goal of manned space flight? Some space officials suggest that a large manned expedition to the Moon should be the next national goal in space. Yet, a second major lunar program seems hard to justify some 25 or 30 years after the first one. The only purpose for a return to the Moon would be to carry out some important lunar-based task, such as a search for extraterrestrial intelligence once the radio frequency environment of Earth becomes too crowded to hear faint signals that may be reaching us from other planetary systems. Such a lunar endeavor would make best sense for the United States as a cooperative international effort, to some extent paralleling the international efforts that have been made in Antarctica.

Inescapably, the key question for US civilian space planning is, "Should we commit ourselves now to sending Americans to Mars?"

Planet Mars has always been alluring to humans. Close-up images of Mars reveal remarkable terrain and fascinating polar regions. It is natural that adventurous humans should travel there as soon as possible, just as the Arctic, the Antarctic and the Moon attracted intrepid human explorers in the past.

The other planets are far less attractive as potential destinations. Venus is hot enough to melt lead, with a crushing atmospheric pressure nearly 100 times that of Earth. Jupiter is surrounded by lethal radiation belts far more intense than those of Earth. Mercury's airless surface is similar to the Moon's but is bombarded by 10 times the amount of solar radiation. Mars, by comparison, is not only survivable but, in the long run, habitable. Oxygen and drinking water probably can be extracted from surface materials. Indeed, some even advocate eventual colonization of Mars, but such decisions may best be left to our descendants.

Organizing the Voyage

How should humans organize the first voyage to Mars? The experience of *Apollo* suggests that an all-out national competition to be first will prevail unless US and Soviet leaders decide to collaborate. To be sure, the Soviets abandoned the Moon race, but only because they realized they could not match the strong US program.

The US choices are:

- ☐ to compete with the Soviets to reach Mars first,
- ☐ to collaborate with the Soviets in the first human exploration of Mars,
- ☐ to not go at all and risk second-rate status as a spacefaring nation in the next century.

The United States could surely win a race to Mars. It has a tremendous technological head start. The Soviets lack manned lunar experience and have no shuttle flights yet. But the reasons for the race to the Moon no longer apply. The United States is the world leader in space technology. It is highly respected — indeed, in some ways feared — because of it.

If the two superpowers were to agree to work together to send humans to Mars, both countries would benefit immediately through the reduction of domestic and international anxiety and through international support for the superpowers' creative leadership. Indeed, such a long-term and substantial commitment to cooperation would be received, first in disbelief and then in joy, by a world dispirited by decades of fear of nuclear war.

Moreover, a joint mission might appeal to the leaders of both superpowers because it would allow each nation to share and defer the huge expenditure involved. It would also help them manage the domestic groups and bureaucracies that have developed a vested interest in manned spaceflight.

It would be technically feasible for the United States to launch a unilateral manned Mars mission at least as early as 2003, 17 years from now. *Apollo* required only eight years from inception to launch. A plausible Mars mission would use two large interplanetary cruise spacecraft, each launched by giant multi-stage propulsion systems ferried up to space and assembled at a space station. [See the March/April 1985 *Planetary Report*.] A crew of four would travel in the first vehicle along with a Mars orbiter and a special ascent/descent vehicle.

The ascent/descent vehicle, analogous to the *Apollo* Lunar Module, would then carry three of them to the surface of Mars for a 30-day stay. There they'd investigate the planet, collect soil and rock samples and perhaps prepare the way for subsequent missions. The crew would return to Earth aboard the second interplanetary cruise vehicle, arriving home in 2006.

Technological Basis

The technological basis for manned spaceflight to Mars is much stronger now than comparable missions to the Moon were when the *Apollo* program was initiated in 1961. Projected costs reflect this difference. *Apollo* represented about a $75 billion expenditure, and the shuttle has cost so far about $17 billion (in 1984 dollars). The hypothetical manned Mars mission is estimated to cost $40 billion.

A joint US-Soviet mission would resemble the mission described above. But it could proceed on a much more leisurely and affordable schedule, perhaps aimed at a landing during the 2015-20 time period. A return to the Moon for extended human-tended scientific experiments could be scheduled in the intervening years.

A collaborative mission would necessarily require substantial technology efforts of both countries. These should be as consistent as possible with the existing trends of the individual national space programs. NASA's shuttle focus would make it logical for the United States to concentrate on the future task of ferrying structures to space, and there to assemble the launch vehicle. The Soviets, on the other hand, have evidenced considerable interest in long missions and have operated a nearly continuously manned facility in Earth orbit for many years. (Indeed, it is only as preparation for human travel to Mars that a logical rationale can be found for such long flights.) Thus, the large interplanetary cruise vehicle could be developed by the Soviets from their *Salyut* program, its capability being increased to include artificial gravity.

Having the two countries develop the most expensive and long lead-time items for the joint Mars flight within the context of their individual national programs would also minimize near-term information transfer problems. If the Mars orbiter and the ascent/descent unit, for example, were developed later, each side would be shielded to some extent from losses if the other country withdrew from the program. The Earth-orbital hardware being developed by each country still would be useful for other national purposes. If one country pulled out of the Mars mission, the other also might choose to develop the additional systems it needed over a longer period so it could go to Mars alone.

There would be opportunities for other countries to participate in the Mars mission through the development of specialized equipment, in return perhaps for the selection of one of their nationals as a Mars voyager.

Besides general planning for the future, US-USSR coordination on unmanned missions to Mars would be expected. The Soviet Union is preparing an important mission to land an unmanned probe in 1989 on the Mars moonlet, Phobos, and also to study Mars from orbit. The United States has scheduled a smaller mission dedicated to remote sensing of Mars from low polar orbit in 1991-92. Both countries could agree to coordinate these two missions to maximize their scientific value.

Policy Questions

While a joint manned mission is technically feasible, many policy questions would have to be resolved. First, could the United States persuade the Soviets not to try to go to Mars on their own but to collaborate? I think so, because the United Sates has significant leverage due to its considerable technological lead. The United States must therefore make clear to them that it will not be second in going to Mars. It will either enter a valid collaborative program with them or arrive there first. How can each side be sure the other is not misleading it? The technology required to go to Mars is of such vast scale on Earth that it is easily monitored. In addition, a system to take humans to the Moon and to Mars would have to be flight-tested on long Earth-orbital tests. There would be little danger that the Soviets could surprise the Americans, or vice versa.

The task for a President committed to a collaborative Mars mission would be to convince the Soviets that the United States is serious about going to Mars — alone, if need be — without immediately locking the country into an expensive, all-out race. To accomplish this, the President need not set a specific date for a mission, nor ask for a major budget increase for manned spaceflight. Instead, the President should require that the space station be designed specifically to provide for the eventual launching of a manned vehicle to Mars. This is not a current requirement. In addition, the President should commit the United States to an automated rover mission on Mars in the mid-to-late 1990s. Such a mission would be essential to gain the information needed to design human landing and mobility systems. He could offer this mission as a collaborative one, making it clear that the United States will go alone if the offer is refused. If both countries were to collaborate, automated sample return might also be included.

These actions would convince the Soviets that, if they choose not to collaborate, the United States is going to Mars first. They would also set a much-needed long-term direction for the US space program. Indeed, the unprecedented disarray in all US space efforts triggered by the *Challenger* tragedy cannot now be overcome without explicit presidential direction. The President must determine not only how the United States is going to return to space, but also its destination.

Whether accepted or not, a genuine offer to the Soviets to collaborate on going to Mars would benefit the United States' relations with the rest of the world. For relatively small financial commitments in the near term, the President could set the United States on a track to Mars and maximize the possibility of Soviet collaboration while ensuring that the US remains first in space.

The civilian space program can once again be used to achieve national goals. To join with the Soviets in going to Mars would be a bold new way to use space for international leadership. It would also constitute a particularly good use of NASA. The program would be scientifically and technologically challenging, it would be intrinsically open and international, and it would involve the highest level of adventure. Most of all, it is all about peace, and hope and imagination — the stuff upon which NASA has flourished. A second Golden Age of civilian space can be achieved. Space in the service of priority human needs could become the symbol of an enlightened and vigorous 21st century for the United States and the world.

Adapted from an article in the Spring 1986 issue of Issues. *Bruce Murray is Vice President of The Planetary Society.*

There Is Life on Mars, and It Is Us!

by Ray Bradbury

Back in the late summer of 1985 I was asked to testify before the National Commission on Space. I accepted, and then wondered why I had accepted. A moment of panic ensued.

Good grief, I thought, I'll be up there amongst a goodly mob of scientists, technicians, super experts, men and women whose knowledge outruns mine by several thousand light years. How dare I speak, and speak only with a poet's heart? Why would anyone listen to me about those future projects into which tonnages of will and knowledge, manpower and bank accounts will be invested?

But go I would, and speak I did.

Even as I must speak now for that very special planet Mars.

Even as it was with those other talented people gathered before the Space Commission, the writers appearing around me in this special issue will probably address technical problems having to do with everything from funding a Mars base to preserving same, with all the attendant political and psychological problems.

I must sing the same old libretto from the same old, I hope, beautiful space opera having to do with life, eternity, distance, time, survival and the puzzlements of mankind.

Let us first pose the question: Mars, why bother?

Sir Edmund Hillary's response to Everest, "Because it's there," has always left me disgruntled and dissatisfied. It is vague to the point of

being opaque. I find a better answer in *Moby Dick*. When asked why he pursued the White Whale, Ahab touched his heart with his fist and cried, "It profits me here!"

And if you do not wish to hear mad dark Ahab, then listen to his twin, mad bright Nemo, Verne's superior captain who if he were alive today would say: "Do not kill the Whale, build the Whale, live in it, scour the seas and then the air, spreading light, and then at last move beyond, and take your heart's blood, mind, soul and imagination to not an imagined heaven but to one most real and, oh look, attainable!"

And if Verne never put those words in Nemo's mouth, I hope you will allow me, a true son of your old Uncle Jules.

For we do not go to Mars because it is there, but because we *must*.

The thing that moves us is as mysterious as the enzyme which engineers the DNA, plays "Simon Says," and the multitudinous matter responds. "Yes?" says Enzyme. And "Yes!" responds DNA.

If I were George Bernard Shaw I could make a better essay than this, for it is an immense subject and requires the young bright wit of that never old man to turn it upside down and inside out. If there is a subject in the world that Shaw did not address himself to, I cannot name it. Given my task here on this page, he might well have declared: "Life force, whatever that is, as super Enzyme, cracks an order, and Mankind as super DNA responds, salutes, and runs to act out the universe."

The secret of why we *must* do anything is locked in our genetics. It will only leap out though actions. And when we have manned the Moon and laid forth some fragile architectures on Mars, in the very doing we will have our answers. Looking back at Earth, we will give the great shout of laughter: "I'll be damned! Yes! We hoped it was right. Now we *know* it was right. Forever!"

And someday we'll not only prevail on Mars, but move on out.

Let us go back to Shaw for a moment.

I so loved him and his pulpit preachments and prefaces that, a few years ago, I built him as a robot, GBS MARK V, and sent him into space, so that, late nights, I could wake him and ask for pronouncements

ILLUSTRATIONS: S.A. SMITH

and hear him lilt once more on the life force and great star fields.

In a sermon barked long before my birth, Shaw, in a few words, which was unusual, gave me the core of the idea that I grew into a pomegranate with a skin around it.

What Shaw said in essence was: "What are we in the long night of time? What is this thinking, idea beast? Why, we are matter and force, making itself over into imagination and will."

There you have it. It describes for all time, for me anyway, what we are up to with our astronautics and our vacations in space.

No use having pure matter and brute force, if it knows not itself. We

know ourselves. But no use knowing unless there is a doing. And in the doing, no use has will power if you have no power to imagine, and no use imagining if you have not the will power to engine it along.

We are the composite thing, then, come alive out of blind matter and dumb force.

And we will ourselves to dream, to blueprint, to build, to move, and finally, to fly.

And the object of our will is Mars.

In the beginning, anyway.

To all this, let me add another, a titanic, factor.

For tens of centuries, mankind has hoped for, prayed for, searched for a substitute for war.

We have now the substitute.

We have always needed to test ourselves against time, circumstance, force and gravity. In the past, this has resulted in such conflicts as destroy the spirit and offer an end product of despair.

We have always needed something to die for, and have done so unto madness.

Now we have something to both live and die for: Mars, space and beyond.

Along the way to Mars, and on the red plains and amidst the deep ravines of Mars itself, we will surely die through misadventure, sheer accident. No need for any war here save the good one of survival, the huge conflict that will test our need for air, food and civilizing environments on far worlds.

It will then be a war worth fighting, one of the few great battles of immense worth in the long history of our being. It can be a truly proud flag we carry as a symbol of light, which is humanity, winning out over dark, which is the place between the stars. If we are, as we know, the stuff of stars, we but carry that old fire back up to the fires from which we descended.

Mars, then, is the next step after the Moon where we will give new meaning to an old and much damaged word: religion. In its origins, it comes from the Latin *religio*, to bind together, as with a leather ribbon encircling sticks. Or to relate ourselves, as sticks are related to one another by bundling, to the universe. Man, the idea beast, eyes the heavens, knows that it is him and he is it, and in that knowledge goes in search, finds, and moves yet farther along.

Well, there you have it.

An excuse, if excuse we need, for packing up to go ajourneying, and the journey will never end. Earth the seedbed, Moon a way station, Mars a short delay of perhaps 400 years, before we try at living forever, which means making landfall out near Alpha Centauri with the starships we must, I repeat must, build.

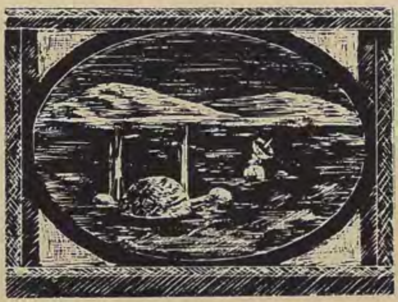
Can we do this and not care in the doing, can we do this and not love all our doing, can we do this and not survive for several hundred thousand additional years?

The wave of the future rushes in a dark tumult toward us.

I, responding to the challenge, say we can. I will us to begin.

We are the Martians, now.

Planetary Society Advisor Ray Bradbury's most recent novel is Death Is a Lonely Business, *published by Alfred A. Knopf, Inc. 1985.*



Let's Go to Mars Together

Above: A multinational team of explorers constructs a shelter on Mars, a first step toward a human outpost. Scenes like this could be televised back to Earth every day, involving the entire human species in the exploration of another planet.

Painting: Pamela Lee

by Carl Sagan

Mars beckons, a storehouse of scientific information — important in its own right but also for the light it may cast on the environment of our own planet. If Mars once had abundant liquid water, what went wrong? How did an Earthlike world become so parched, frigid and comparatively airless? Is there something here we should know about our own planet?

We humans have been this way before. Christopher Columbus would have understood the call of Mars. But mere scientific exploration does not require a human presence. We can always send smart robots. They are much cheaper, and you can take more risks with them.

Sending humans to Mars must have more than scientific justification, as with the *Apollo* program. President John F. Kennedy did not ask to find out the origin of the dark lunar lowlands by the end of the 1960s; he asked for an American to land on the Moon and return safely. It was an American political response to the Bay of Pigs fiasco in Cuba and to the fact that the first person to orbit Earth was a citizen of the Soviet Union. And, as all the world knows, that race the Americans won.

But imagine a different sort of *Apollo* program, in which cooperation, not competition, was the objective, because the leaders of the US and the USSR had come to their senses. Imagine these leaders deciding to do something not just for their nations but also for their species, something that would capture the imaginations of people everywhere and would lay the groundwork for a major advance in human history — the eventual settlement of another planet.

It can be done. It is technologically feasible. It requires no major breakthroughs. A project to send people to Mars sounds absurdly expensive. But the advances in technology have been so great that such a mission would cost far less than Star Wars [the Strategic Defense Initiative], less than the *Apollo* program, and not much more than a major strategic weapons system. In a joint mission, the cost to any one nation would be still smaller.

But why a joint mission to Mars? Why not jointly feed the hungry in sub-Sahara Africa, or do water reclamation projects in Bangladesh? The United States and the Soviet Union could, if they chose, together help house, educate, provide medical care for and make increasingly self-reliant every citizen of the planet. But the US and the USSR have no such precedent; they have been obsessed by the pursuit of short-term competitive advantages. The political realities, sadly, are that a joint mission to Mars, like *Apollo/Soyuz*, is well within the realm of practical possibility, while many worthy and more mundane activities are not. Not yet. But a major cooperative success in space can serve as an inspiration and spearhead for joint enterprises on Earth.

Moreover, space missions have an important subsidiary advantage: They use precisely the same aerospace, electronics, rocket and even nuclear technologies as does the nuclear arms race. There is a perception, enunciated most clearly by President Dwight Eisenhower in his farewell address, that the marriage of high technology and the military establishment creates an arms-race juggernaut that is almost impossible to turn off and that may destroy us all. An alternative program using the same industries and some military skills for peaceful purposes might be a very good thing; it is foolish to have powerful vested interests — jobs, careers, profits, dividends — mainly dependent upon a continuing arms race. Expeditions to the planets use the same high technology, and the traditional military virtues of organization and valor, in a humane and benign cause.

Voyages by humans to Mars simultaneously engage many different constituencies: technological, scientific, exploratory, military and industrial, as well as the many who wish to see significant, balanced cooperation between the United States and the Soviet Union. Some people feel the lure of Mars simply as the future calling. A joint Mars project excites both visionaries and practical engineers, crosses national and ideological boundaries, and even — as I discovered at a meeting of scientists and world religious leaders in Italy — has a powerful and ecumenical religious appeal. There is, it seems, a tide rising.

With or without the United States, the Soviet Union is going to Mars. Since before *Sputnik*, the Soviets have declared their long-term intention to go to Mars. Yet, to date, even with the first unmanned landings on the Moon and on Venus to their credit, they have never been able to land a working spacecraft on Mars. However, an extremely ambitious dual spacecraft launch to Mars is intended, according to Soviet scientists, for 1988-89. The two unmanned vehicles will insert themselves into orbit around Mars and approach, very closely, not Mars itself but its two small moons, Phobos and Deimos. Four years later, another Soviet Mars mission is planned.

The Soviets have kept men in space for eight months and sent one cosmonaut on two consecutive missions, each of six months' duration. Why? In the vicinity of Earth, there is no mission that requires such long stays in zero gravity; certainly any future space station will have shorter

This article is excerpted from a feature that appeared in the February 2, 1986 issue of Parade *magazine.*

duty cycles. But it takes roughly nine months for a spacecraft to journey from Earth to Mars.

On the launch pad at Tyuratam, a massive rocket booster is being completed, a heavy lift vehicle comparable to the *Saturn 5* that took the *Apollo* astronauts to the Moon. The Soviets have two more or less continuously occupied space stations called *Salyut* and *Mir* and are developing the equivalent of a shuttle to low Earth orbit and a space tug.

A Soviet manned landing on Mars in the early 1990s, say, seems unlikely. It is too soon. But a Soviet mission to carry cosmonauts on a close approach to Mars is much easier and just possibly might be launched by 1992. The date is significant — it is the 75th anniversary of the Russian Revolution.

But 1992 is also the 500th anniversary of Christopher Columbus' discovery of what came, propitiously, to be called the New World. Whatever the original motivations were for the age of exploration that Columbus ushered in, the net result has been, in a painful historical process now nearing completion, the linking of the continents, the unification of the world. What could be more fitting for 1992 than the initiation of an international program for the exploration and eventual settlement of another New World? Perhaps by 1992 the nations would merely begin assembling in low Earth orbit the components of the spacecraft that will take the first humans to Mars.

If we take this path, there will come a time — perhaps at the dawn of the new millennium — when the interplanetary spacecraft will be completed in Earth orbit, the progress in full view on the evening news. Astronauts and cosmonauts, hovering like gnats, will guide and mate the prefabricated parts. The day will come when the ship is tested and ready, boarded by its international crew and boosted to escape Earth's gravity. For the whole of the voyage to Mars and back, the lives of the American crew members will depend on their Soviet counterparts and vice versa, a microcosm of the actual situation down here on Earth. Perhaps the first joint manned (and womanned) mission will be only a flyby of Mars. Perhaps robot vehicles will then (or earlier), with parachutes and retrorockets, gently set down on the martian surface to collect samples and return them to Earth. But eventually — around 2001 if we wish it — humans will set foot on the planet Mars.

According to solemn treaty, signed in Washington and Moscow on January 27, 1967, and ratified by the Senate and the President, no nation may lay claim to part or all of another planet. Nevertheless — for good historical reasons that Columbus would have understood well — people are concerned about who first sets foot on Mars. If this really worries us, we can arrange for the ankles of the American and Soviet commanders to be tied together as they alight in the gentle martian gravity.

But there would be much to do besides making symbolic gestures. The crews would acquire new and previously sequestered samples, in part to search for life, in part to understand the past and future of Mars and Earth. They would experiment, for later expeditions, on extracting water, oxygen and hydrogen from the hydrated rocks and sand and from the underground permafrost — to drink, to breathe, to power their machines and to fuel the rocket for the return to Earth. They would test out martian materials for eventual bases and settlements on Mars.

And they can go exploring. For me, the early stage of human exploration of Mars is encapsulated by the image of a roving vehicle wandering down an ancient river valley, the crew with geological hammers, cameras and analytic instruments at the ready. Every day the explorers could rove to their own horizon, their discoveries televised back to Earth at the speed of light.

In the long run, the binding up of the wounds on Earth and the exploration of Mars might go hand in hand, each activity aiding the other. The wonders of Mars will occupy us for a long time — its surface area is equal to the land area of Earth. The first voyage of men and women from our planet to Mars is the key step in transforming us into a multi-planet species — a step as momentous as the colonization of the land by our amphibian ancestors some 500 million years ago and the descent from the trees by our primate ancestors perhaps 10 million years ago.

Decades ago, Mars called to the Soviet spaceflight pioneer Konstantin Tsiolkovsky and to his American counterpart, Robert H. Goddard. The rockets they designed were intended not for the destruction of life on Earth but to take us to the planets and the stars. Is there not some special obligation of the two principal spacefaring nations — the two nations that have burdened our planet with 55,000 nuclear weapons — to put things right, to use this technology for good and not evil, to blaze, on behalf of every human being, the trail to Mars and beyond?

Carl Sagan is the David Duncan Professor of Astronomy and Space Sciences at Cornell University and the President of The Planetary Society.

Above: Before astronauts and cosmonauts set out together for Mars, they will have to learn to work together in Earth orbit. Here artist Andrei Sokolov imagines a rendezvous between a US space shuttle and a Soviet Salyut space station.

Painting: Andrei Sokolov, Space Art International

Below: Human explorers of Mars will probably be preceded by robotic explorers, such as mobile spacecraft, or rovers, that can traverse the martian canyons and plains, gathering samples for a companion craft to return to Earth for detailed analysis.

Painting: Ron Miller

VIKING

Reflections After Ten Years

BY JAMES S. MARTIN, JR.

5:12 am PDT — July 20, 1976 — *Viking 1* landed on the surface of Mars, the culmination of 9 years of work for me, 15 years for some colleagues. It was 7 years to the day since *Apollo 11* had landed on the Moon.

That morning had started *early*. Driving to Pasadena's Jet Propulsion Laboratory around midnight, all I could think was: "The moment of truth is at hand." In a few hours the *Viking* Lander would separate from its Orbiter, to proceed without human intervention to a rendezvous on Mars.

I was confident that the Lander and Orbiter would work. The Martin Marietta Lander Team, led by Walt Lowrie, had done a superb job designing, developing and testing the Landers. The JPL Orbiters, with their *Mariner* heritage and an experienced team led by Henry Norris, had performed perfectly during the 11-month cruise, orbit insertion and landing site selection.

But would Mars cooperate?

We had searched for an acceptable landing site for over a month. Now it was clear that our knowledge of the martian surface was marginal at best and, at the scale of the Lander, three meters — we knew almost nothing.

The Orbiter and Lander separated on schedule, and at 1:51 am spacecraft telemetry indicated that all went well. The Lander was heading toward the surface. At 4:53 am, the "Voices of *Viking*" (George Sands and Al Hibbs) reminded us that the Lander should be on the surface — one way or another. The next 19 minutes, waiting for the Lander's radio signal to reach Earth, seemed to take forever. Only the continuing stream of nominal telemetry data eased our anxiety pains. The parachute deployed on time; the descent engines started. Forty seconds later, at 5:12 am, Dick Bender, the Lander Performance Deputy Team Chief, called out, "Touchdown, we have touchdown!"

Mars did cooperate. We'd found a safe landing site on Chryse Planitia, the "Golden Plain," at 22.4 degrees North, 47.5 degrees West.

My heart began beating normally again. We had finally landed on Mars, a first for the United States. The painful memories of the past years, of struggling with the "Top 10 Problems" list, quickly dimmed. Now we could get to work collecting scientific data. Forty-two minutes later, the first picture of the martian surface started to arrive, line by line, on the television monitors. Thomas A. (Tim) Mutch, the Lander Imaging Team Leader, described the first pictures for the public and the press. "It's incredible!" punctuated his explanations about every 15 seconds.

It *was* incredible. Mars was about 350 million kilometers (200 million miles) from Earth and *Viking* was returning pictures as clearly as if it had taken them in Death Valley.

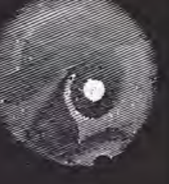
Sleepless Nights

However, I will never forget the sleepless nights, the endless meetings and the seemingly impossible task of finding a safe landing site.

On June 19, 1976, the *Viking 1* spacecraft (Orbiter and Lander) had been placed in orbit about Mars with incredible precision. The designed orbital period was 42.6 hours; the achieved period was 42.4 hours. The designed periapsis (closest approach to the planet) was 1,511 kilometers; the actual was 1,514 kilometers, only 3 kilometers higher. This remarkable feat was due, in large part, to the Navigation Team, led by Bill O'Neil of JPL. In the days to follow, Bill's team continued to amaze me with their ability to plan and achieve uncannily accurate trim maneuvers, usually with minimal notice. JPL's navigational capabilities are world-class.

On June 21, a trim maneuver was performed so that the spacecraft would reach periapsis over the pre-selected landing site at 19.5 degrees North and 34 degrees West. We planned to photograph the landing site in detail so that we could select the precise site for a landing on July 4 — the bicentennial of the United States.

But this time, Mars did not cooperate. The first pictures, while exceptionally clear, revealed channel features that strongly suggested the flow of water or other fluids on Mars. We saw flow lines in many places on the channel floors, water lines on islands, and teardrop-shaped islands in mid-channel.



Crisis Over Chryse

As Viking 1 approached Mars in early 1976, the spacecraft was headed for a landing in the Chryse region, near the mouth of Valles Marineris, the "Grand Canyon" of Mars. The site had been selected after many months of discussion by project scientists and managers. They had based their selection primarily on images returned by Mariner 9, which had entered orbit about Mars in 1971. When Viking 1 reached Mars, it was to photograph the "A-1" site so it could be certified safe for landing. But then the first image came in . . . .

On the evening of June 22, 1976, the Landing Site Staff was holding its fifth meeting in what was to stretch into a series of 48 sessions before both *Viking* spacecraft were on the surface. During their early discussions, the scientists had concentrated on the readiness of men and machines to certify the landing regions. In the midst of another theoretical session on the problem

Early morning on a martian desert, as seen by Viking 1. *Image: JPL/NASA*

The Site Selection Team, led by Hal Masursky of the United States Geological Survey, and the Orbiter Imaging Team, led by Mike Carr, also of USGS, were astounded by these first pictures. *Viking*'s Mars was very different from that photographed by *Mariner 9*, which had reached Mars five years earlier. Apparently the dust had never settled during the *Mariner 9* mission, obscuring the surface details. What we had thought to be gently rolling topography now had become sharp lava flows and fluvial channels.

It quickly became clear to me that we did not understand the geological processes at the prime site and that the unexpected surface features and texture added potential hazards we could not cope with.

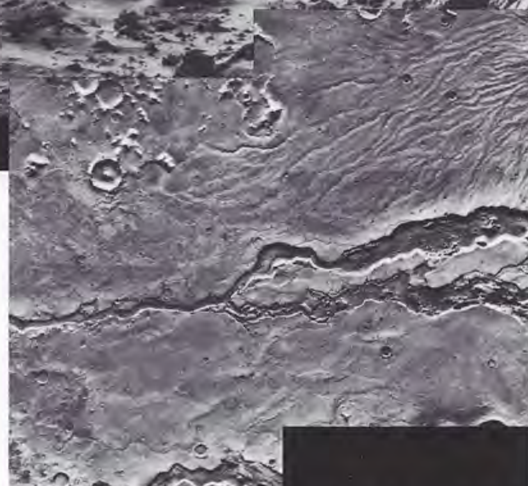
Delaying the Landing

Therefore, I decided not to land on July 4, and to study alternate landing sites. For this first mission to the martian surface, a safe landing was the only consideration. As I said to the press at JPL on June 28, "If one sets off as Columbus did to find a new world, he need not apologize for looking for a safe harbor."

While many were disappointed by the landing delay, I was very pleased that the NASA management, including Administrator James C. Fletcher, supported my decision.

The entire flight team, led by Mission Director Tom Young, prepared detailed plans to use the Orbiter to photograph alternative sites for analysis. This was not a simple task. To move the orbit periapsis required precise navigation calculations, spacecraft sequences and commands, identification of alternate landing sites and countless hours of crater-counting and photo interpretation. From June 23 to July 12 the flight team commanded five orbit trim maneuvers to better photograph seven or eight potential landing sites. There were landing site meetings at least once a day — sometimes two or three.

Ground-based radars at Goldstone, Haystack and Arecibo were used to indicate the roughness of potential sites. I had difficulty in believing radar observations as definitive data sources. Proponents such as Len Tyler and Von Eshleman were convinced that radar could "feel" surface roughness measured in meters, whereas Orbiter pictures could not resolve features smaller than a football field — about 100 meters. It seemed to me that the smoothest visual sites were always portrayed as rough in radar observations. During one meeting, I recall Carl Sagan saying one of the early candidate sites →



Scientists were stunned by the complex textures and landforms revealed by Viking Orbiter 1. Later processing of the images brought out even more details. This is the source region of Dao Valles, a large channel that flows into the Hellas impact basin. The ridges and valleys in the upper right are degraded lava flows from Hadriaca Patera, a very old shield volcano (out of view to the north in this image). ***Image: Tim Parker, JPL/NASA***

of extrapolating downward from the scale of the images produced by the orbital camera system to the size of the Lander, reality intruded. At 6:09 pm, the first picture of the landing site appeared on the overhead television monitor in the meeting room. Gentry Lee later told the press, "You would have believed that all the people in that room were 10 years old because we all got up and 40 of us ran over to the scope and watched it come in line by line." Mars as viewed by *Viking 1* did not look like the planet photographed by *Mariner 9*. Their landing site, chosen after years of debate, lay on the floor of what looked like a deeply incised riverbed. Surprise, shock and amazement only began to describe the specialists' reactions to this first picture.

Mike Carr recalled his feelings when the Orbiter Imaging Team began to look at the data in detail. "We were just astounded — a mixture of elation and shock." They were elated at the quality and detail of the pictures but shocked at what they saw. All their data-processing schedules had been based on a preconceived notion of what Mars should look like, and this was not it. The night of June 23 stretched into morning as Building 264, which housed the *Viking* scientists working at JPL, became a beehive of activity. The Orbiter Imaging Team was busy arranging photographs into mosaics, counting craters and evaluating the geological nature of the region. All that they saw — the etched surfaces, the multitude of craters and islands in the channels (all at the 100-meter scale) — told them that the A-1 site was not a suitable place to land.

* * *

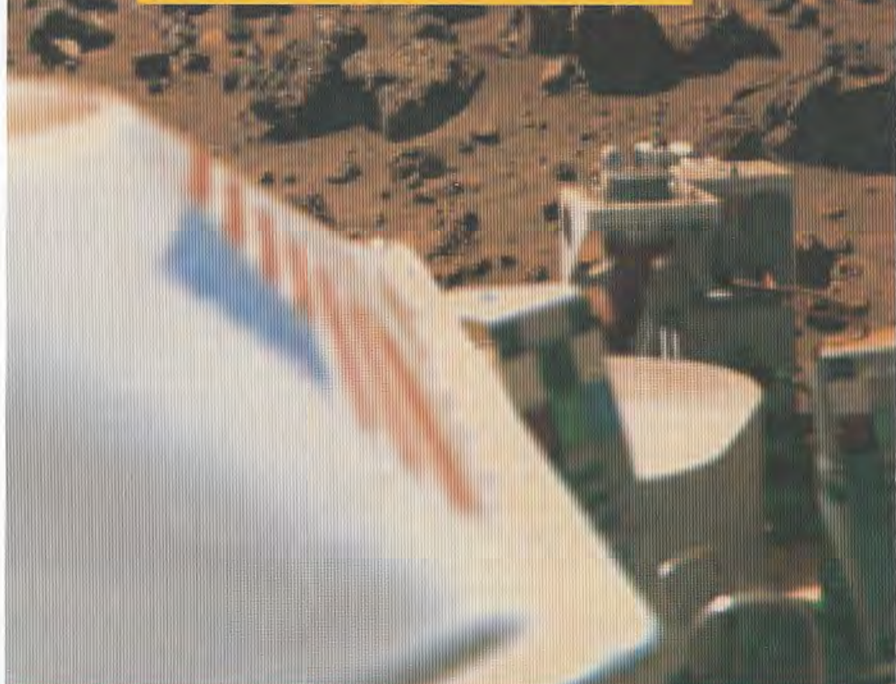
At a June 24 *Viking* press briefing, Lee explained what was going on behind the scenes. Between 300 and 400 persons participated in the site certification process. When the pictures came down from Mars, JPL, the USGS Astrogeology Center at Flagstaff and several other organizations went to work. Every night, a Landing Site Staff meeting was held, divided into two portions — operational and analytical. Were the photos, mosaics, maps and the like acceptable and on time? What did it all mean? To find a safe place large enough for a landing ellipse, the team would need more photo coverage.

Two landing site meetings were held on the 25th. The discussions centered on one key question, "Do we continue

(continued on page 14)

A complex system of overlapping lava flows lies on the flank of Alba Patera, a large shield volcano between 1,500 and 2,000 kilometers (900 and 1,200 miles) across. Compared to lava flows on Earth, martian flows are enormous; those in this mosaic are at least 225 kilometers (140 miles) long. Image: Dale M. Schneeberger, JPL/NASA

The great martian volcano, Olympus Mons, towers 25 kilometers (16 miles) above the surrounding plain. The largest volcano on Earth, Mauna Loa, rises only 8 kilometers (5 miles) from the ocean floor. Image: JPL/NASA



Viking Lander 1 snapped its own picture while sitting on a rock-strewn plain, sho

had areas with good quality pictures and mediocre radar, or vice versa. Carl wanted good radar and good photos. While I always suspected the radar data, I found it difficult to argue with Sagan, Tyler and Eshleman. I believed that there must be somewhere on Mars that a consensus would say was a safe landing site.

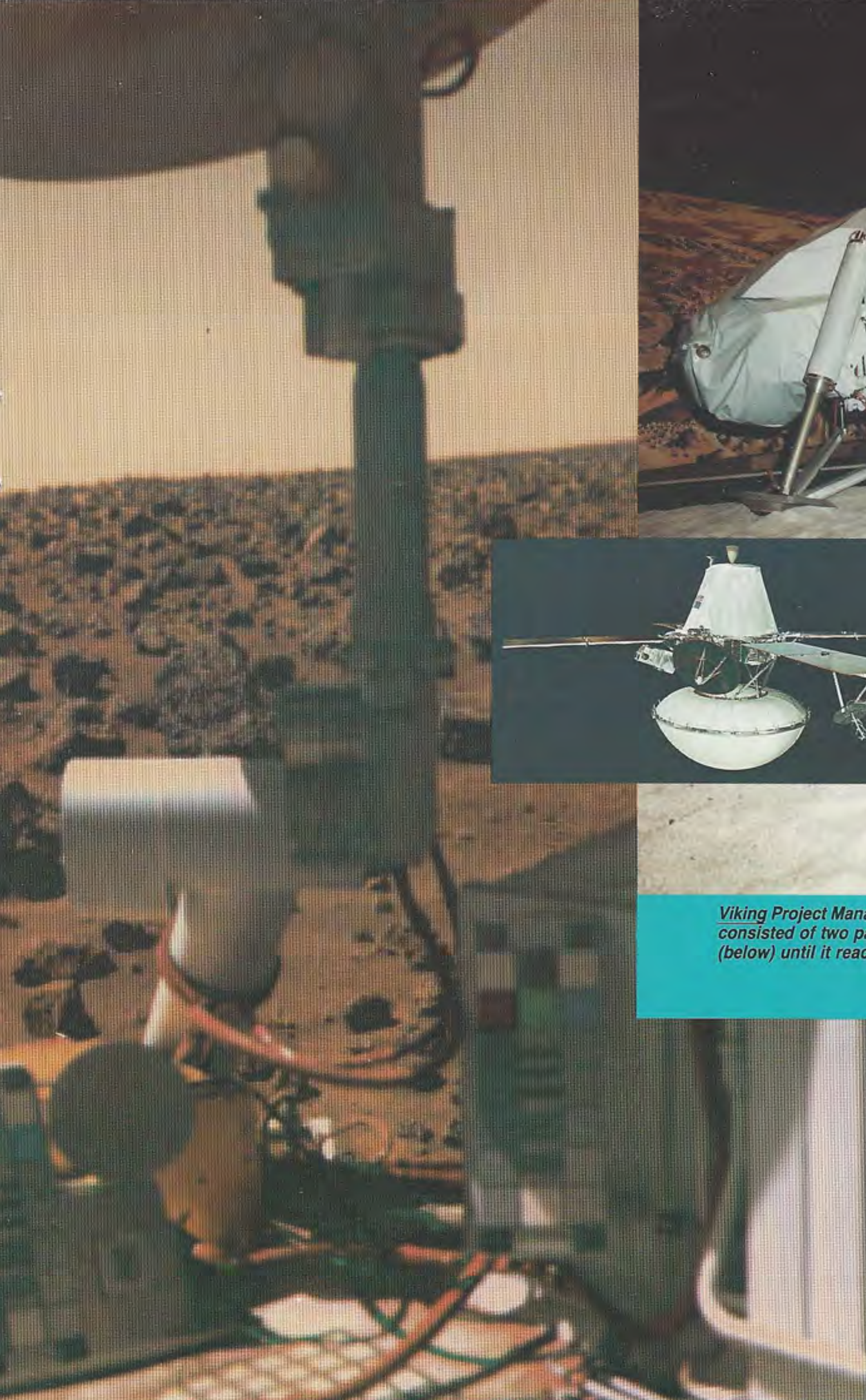
While we were struggling to find and certify a landing site for *Viking 1*, *Viking 2* was rapidly approaching Mars. Launched on September 9, 1975, *Viking 2* would arrive at the planet on August 7, 1976. The wishes of the Project Manager had no bearing on its arrival. It had to go into orbit on August 7. Furthermore, our planning had assumed only one active Lander at a time. Our flight team, already the largest in NASA's planetary history, simply could not command more than one active mission at a time. We had to either land *Viking 1* by July 25 or run the risk that one Lander might have to wait until after conjunction (when the Sun would be between Earth and Mars), mid-December 1976, before landing. I could also sense that many members of the flight team were just plain tired. The 16-20 hour days were taking a toll.

Reaching a Consensus

Finally, on July 12, we reached the consensus I had been searching for. The Chryse Planitia site was the unanimous choice. It had both acceptable radar signature and acceptable pictures. The weeks spent searching for the *Viking 1* landing site were over. The project owes team leaders Mike Carr, Hal Masursky and Gentry Lee a vote of thanks for a job well done. Carl Sagan asked the tough questions and challenged pat answers. Tom Young was the general manager for the mission's most trying and difficult decisions; he kept the train on track and on schedule.

I must say a few words about the *Viking* flight team. We had the best, the most dedicated group of engineers, scientists, software specialists, mission controllers, managers and leaders. During the seven years before launch, I selected people from JPL, from Martin Marietta, and from NASA's Langley Research Center to fill key team leadership positions. After I announced the choices, a NASA Headquarters lawyer told me that government employees could not work under contractors; many Langley people were in contractor-led teams. I simply responded that the best people were chosen to lead. The Langley employees were placed where each could contribute his best, the same as all other team members. I think the results speak for themselves.

Thinking back to 1969-76, I still miss the active and challenging association with the *Viking* science teams. We had a vigorous group facing a most difficult task: designing and developing Lander science instruments that could be sterilized before launch, survive launch and the cruise to Mars, endure landing and operate on the surface. Many times I was forced to ask for budget reductions. Each time, Gerry Soffen, the Project Scientist, and the science team leaders responded positively. The Lander camera, the gas chromatograph-mass spectrometer (GCMS) and the biology instrument were on my top 10 problems list most of the time. We all found it difficult to invent on schedule. The scientists played an active



Viking Project Manager Jim Martin poses with a full-scale Lander model. Each *Viking* spacecraft consisted of two parts (inset), an Orbiter and a Lander. The Lander rode in its landing capsule (below) until it reached Mars. Photos: JPL/NASA

wing the folks back home that it had, indeed, landed on Mars. Image: JPL/NASA

role by helping to reduce costs, but more important, by insisting on a quality science investigation.

I was personally disappointed that the "search for life," as the media called the biology investigation, did not yield a clearly positive or negative result. "Semi-positives," coupled with no organics found by the GCMS, makes me want to return to Mars. The Orbiter pictures of dry river beds and islands, and the detection of ice, make me think life could still be present somewhere on Mars.

All in all, the *Viking* mission was an indescribable experience for me. The continuing challenges of budgets, people, technical problems, fixed launch dates and, finally Mars itself, were tough. However, a team of dedicated people, with outstanding leadership at all levels and with a clear objective, can and will succeed. I am convinced that the *Viking* team, several thousand strong, could accomplish any task they set out to do. The failure of our system was that they were only given one opportunity.

In closing, I want to quote from my favorite book on *Viking*, Tim Mutch's *The Martian Landscape*. This is his forecast of the future:

"A tractor drive vehicle, slightly larger than Viking, *could roam up to several hundred kilometers, sampling geological and biological environments inaccessible to* Viking *. . . followed by an unmanned sample return mission. Even if the immediate future is uncertain, I have no doubts about the distant years. Someday man will roam the surface of Mars. Those wonderful* Viking *machines will be crated up, returned to Earth and placed in a museum. Children in generations to come will stand before them and struggle to imagine the way it was on that first journey to Mars."*

I only wish Tim were here to see his predictions come true. (In 1981, he died in a climbing accident in the Himalayas.) *Viking* Lander 1 is now named the Thomas A. Mutch Station in his honor. Someday the Mutch Station will be brought home from Mars.

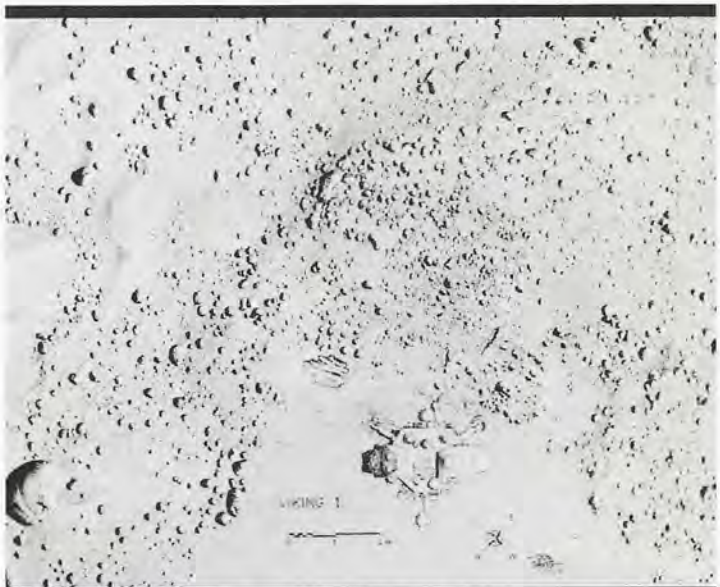
James S. Martin, Jr. was the Viking *Project Manager at NASA's Langley Research Center from the project's inception in 1969 to the conclusion of the primary mission in November, 1976. Now retired from Martin Marietta, he is an active consultant to the Solar System Exploration Division at NASA Headquarters.*

(*Crisis Over Chryse* continued from page 11)

at A-1, or do we prepare to go to A-2 or A-1 alternate?"

At the end of the staff meeting, a straw vote indicated that 20 members of the group favored staying with A-1, while 24 wanted to move on to A-2. Project Manager Jim Martin did not vote, but he indicated that he would take

The great complexity of canyons, channels and craters that score the martian surface was a surprise to Viking scientists. After the first images of the surface revealed that their original landing site was too rough for a safe landing, the project leaders scrambled to find a new site. They settled on this region of Chryse Planitia, which looks smooth and bland from orbit, as portrayed in this map. Map: Don Davis



What looked like smooth, sandy desert from orbit was actually a rock-strewn plain; nevertheless, Viking Lander 1 landed safely. Had it drifted a little to the northeast (bottom left in this map), the spacecraft might have landed on a large boulder, nicknamed "Big Joe," that could have upset it. Map: Don Davis

all the views into account before he decided which course to follow.

Martin was not long in making his decision known. He explained that he had decided not to land at A-1 or A-1 alternate on July 4 because project specialists did not understand the processes that had formed some of the visible topographical features. Without a clear understanding of the geology at the 100-meter scale, predicting what the surface would be like at the scale of the Lander would have been nearly impossible.

* * *

Jim Martin summed up the situation for the press: "The visual images are only really telling us what is observable at 100 meters and up, Rose Bowl size hazards." Len Tyler and his colleagues on the radar team believed that radar "feels slopes, boulders, in the order of a meter or a few meters in size." Martin and his men had a decision to make — go ahead with the plans for a July 17 landing (at a new site called A-1NW) or look for a new site.

* * *

On the 12th of July, the site staff met to consider the insights for the *Viking 1* site gained up to that point. John Guest of the University of London had reviewed the revised and updated geology hazard map and found that neither textured surface nor grooved plains existed in the landing ellipse, except possibly some fine grooving below the resolution limit of the cameras. Additionally, channels disappeared or stopped rather suddenly, and Guest thought this indicative of their being covered over by wind- or water-borne dust or larger particles (a process called mantling) rather than their being below the resolution limit. Hal Masursky believed that existence of this younger, thicker mantling was consistent with the drop in radar reflectivity in that direction. He believed that they had reached the best location for a landing.

Len Tyler presented findings from the continued radar analysis. Tongue in cheek, he suggested that the reflected signals dropped off significantly either because of scattering caused by the surface or because of a hole through the planet. Radar data were once again the subject of considerable discussion among the specialists, but after a couple of hours, Martin closed the session. They would reconvene that night to consider the additional pictures processed by then and reach a decision. If they could not do so quickly, they would meet at 3:00 the next morning and continue to meet until they selected a landing site. Some temper and senses of humor were wearing thin, but Martin continued to display his steady, firm, authoritative manner. A decision needed to be made and he intended to see it through.

Hal Masursky opened that night's session. He saw three possible landing areas: alpha, beta or gamma. After the staff had moved ellipses around the photomosaics (playing what Masursky called "cosmic ice hockey"), counted hazards and evaluated radar, alpha looked best.

The alpha site would be a compromise between the hazards visible in the photographs, primarily impact craters and blocks ejected from them, and the small-scale surface properties "felt" by the radar. A vote was called for, and alpha was the unanimous choice for the spot to land *Viking 1*. The 22nd meeting of the Landing Site Staff adjourned at midnight.

"Crisis Over Chryse" is adapted from On Mars: Exploration of the Red Planet 1958-1978 by Edward Clinton Ezell and Linda Neuman Ezell, published in 1984 by NASA.

A Millennium Project: Mars 2000

by Harrison H. Schmitt

SPACE AND THE UNITED STATES' commitment to space are two of many issues of the future that have been too long neglected as the country's decision makers and the media focus only on this year's obvious problems. Unless we deal with these issues of the future, it won't make much difference to Americans under 40 how well we handle the problems of the present.

As the third millennium turns, the relative levels of national commitment to space will determine the course of human history. If the United States' commitment is small, then other countries will lead humankind into the future. If the United States' commitment is large, then its economy and its culture will lead humankind into that future.

As the millennium turns, the levels of national commitment to space will determine the dominant players in the world economy. As they have for two decades, investments in space-related research, development, science and technology applications will be the wellspring of innovation, new goods and services and, increasingly, new business opportunities.

As the millennium turns, the levels of national commitment to space will determine the course of world economic development. For example, if we are wise enough to transfer the benefits of space technology applications to developing nations, we can ultimately eliminate those four horsemen of worldwide disaster: ignorance, poverty, hunger and disease.

As the millennium turns, the relative levels of national commitment to space will determine whether The Planetary Society's efforts toward greater international cooperation will bear fruit. If the United States' commitment remains half-hearted and uncertain, then other nations will have no incentive to join with us in such cooperation.

The frontier of space has produced a level of excitement and motivation among the young generations of the world that has not been seen for nearly a century. History clearly shows us that nothing motivates the young in spirit like a frontier. It is unacceptable and unrealistic to assume that it will be 50 to 100 years before we reach historic new milestones in space. Some young people are just not going to wait that long.

The unique resources of near-Earth space provide the basis for the creation of an Earth-orbital civilization. The weightlessness, the high vacuum at high pumping rates and the unique view of Earth, Sun and stars can be utilized for industrial, public service, educational, research and peacekeeping purposes.

The Moon and planets offer both challenges and opportunities to excite existing and future generations of men and women just as the New World offered both challenges and opportunities to past generations. The extension of our civilization to the planetary shores of the new ocean of space should be our basic goal for a world Millennium Project: Mars 2000. With the successful completion of Mars 2000 — the establishment of a permanent martian base by 2010 — we should see the first firm steps toward permanent human settlements away from Earth.

No matter what other justifications may be given, the ultimate rationale for today's generations to return to deep space and to establish a permanent presence there is to create the technical and institutional basis for the settlement of Mars. This will be the first great adventure for humankind in the third millennium.

Steadily increasing philosophical and psychological momentum for this adventure is building among young people of Earth. If you have talked with them, you will find that many have their eyes on Mars. They are the ones who will go to Mars. They are the ones, like most of our ancestors before them, who will never be satisfied with either the comforts or the restrictions of home and Earth. These are the parents of the first Martians.

With the establishment of a self-sustaining settlement on the Moon, trading directly with an Earth-orbital civilization of permanent space stations, we will have created the technical and institutional basis to go to Mars with the purpose of establishing a permanent base upon completion of the first few expeditions. These expeditions could be under way by the end of the first decade of the third millennium.

Why the hurry? Why a Millennium Project that stretches our reach to the limit? The answer is in the minds of young people who will carry us into the third millennium. It is in the generations now in school, now playing around our homes, now driving us to distraction as they struggle toward adulthood. They will settle the Moon and then Mars. They will do this because they want to do this. They want to be there. Our role is merely to stay out of their way while we preserve and expand their opportunities.

The answer to "why the hurry" is also in the clear determination of the Soviet Union to establish itself in deep space and on Mars. Long duration Earth-orbital flights by cosmonauts, heavy lift launch vehicle development and their emphasis on future Mars exploration all tell us what the Soviets expect to do before the end of the 20th century. An attempt to launch Soviet cosmonauts to the vicinity of Mars by October 1992, the 75th anniversary of the Bolshevik Revolution, is not only possible, it is highly probable. How sad if the United States missed the opportunity to similarly celebrate the 500th anniversary of Columbus' discovery of the New World.

Mars 2000 will be for the world's children what space stations were to their parents and what *Apollo* was to their grandparents — the embodiment of the best in the human spirit. Perhaps most important, if our own determination is unequivocal, astronauts and cosmonauts may be able to join hands in this great adventure.

How many young people would go to Mars if given the chance? How many would raise their families there? If you ask them, as I have for a dozen years, the answer is: *many*.

There is little technical distance between us today and the realization of all that I have suggested. Certainly, there is little to be done compared to the task that faced us when we began the race to the Moon. Whatever new technical options may be appropriate, now is the time to create those options so that the next generation may proceed when they are ready.

The confidence we can have in discussing the establishment of a permanent base on Mars comes from two directions: the self-assurance and detailed scientific knowledge gained from the *Apollo* expeditions to the Moon and the spectacular information returned by the *Viking* mission to Mars. We know nearly as much about Mars as a planet as we did about the Moon before Armstrong and Aldrin landed there in 1969.

The major unknowns for a Mars 2000 project center on physiological adaptation to weightlessness, the mineral and chemical composition and reactivity of the martian soil and the choice between conventional or low-thrust nuclear rocket propulsion. However, our range of potential technical answers to these questions is so great as to make many certain that they contain no insurmountable roadblocks.

Whatever is ultimately the resolution of various technical issues, space activities will be sustained less by technology and knowledge than by emotions — the emotions of young people the world over. As with our ancestors, their freedom lies across a new ocean — the new ocean of space.

The Millennium Project: Mars 2000 is their hope as well as our mission.

Former lunar astronaut Harrison Schmitt consults and speaks on space, technology and public issues. He is a member of The Planetary Society's Board of Advisors.

PHOBOS SPACECRAFT
Painting: Andrei Sokolov

New Robot Missions to Mars

by Louis D. Friedman
and Alexander Zakharov

Despite the great success of *Viking*, its failure to find life on Mars was an enormous disappointment to many, and certainly contributed to the fact that no further missions have been sent to the planet.

Now, 10 years later, the shock has worn off and we recognize that Mars remains an exciting place. Our understanding of the planet from *Viking*, and the realization that humans perhaps could live there, now provide powerful motivations for more exploration. And the hope of finding signs of life there, past or present, has reasserted itself. The next 10 years will see new robotic missions to Mars paving the way for human exploration in the next century.

Louis Friedman is formerly the Project Leader of the Advanced Mars Program at the Jet Propulsion Laboratory. Alexander Zakharov is Project Manager of the* Phobos *mission at the Institute for Space Research, Soviet Academy of Sciences.

△ LANDING ON PHOBOS △

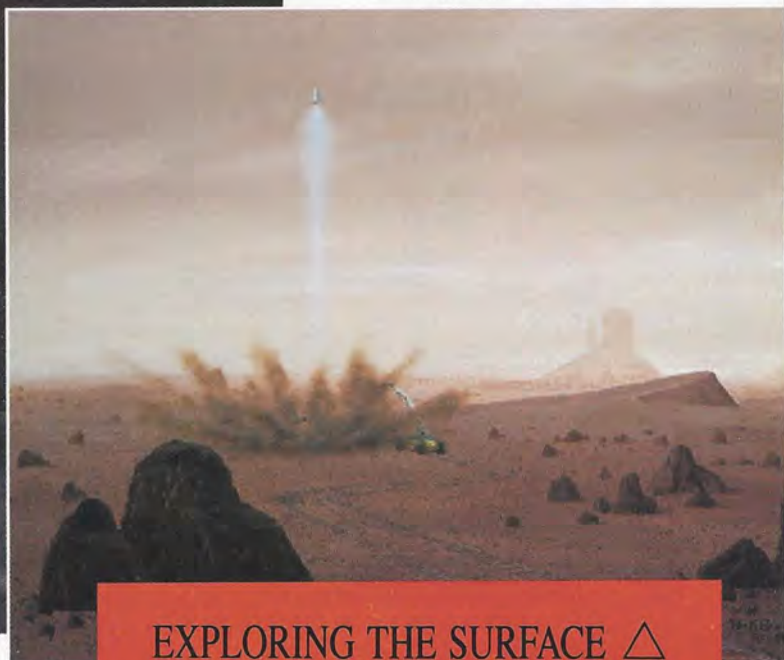
The first scheduled mission is the 1988 Intercosmos *Phobos* mission (Intercosmos is a Soviet-led team of East European nations). The spacecraft is named for its target, one of the two small moons of Mars. The multipurpose mission will study Mars from orbit and the Sun from interplanetary space. It involves innovative plans for experiments at Phobos, including firing a laser at the satellite to ionize surface material. The resulting cloud can then be analyzed by the spacecraft hovering 50 meters above. From this altitude, the spacecraft can take images of the surface revealing features as small as one centimeter across.

Intercosmos is discussing two possible landers for the mission: a hopper to take measurements at several sites on this moon, and a long-lived lander that could be tracked from Earth for about a year — in a cooperative experiment with the United States. Soviet scientists also plan radio sounding of Phobos.

The spacecraft will image Phobos in both infrared and visible light, and also observe the satellite with a gamma-ray detector to determine surface composition. Several experiments will study the martian atmosphere, magnetosphere and ionosphere.

As with the *Vega* mission to Venus and Halley's Comet, the several members of Intercosmos, and possibly other nations, will contribute scientific and engineering expertise. The mission will be launched from the Soviet Union in 1988 and arrive at Mars 200 days later. Analysis of the interplanetary trajectory suggests that the spacecraft will make its closest approach to Phobos on May Day, 1989.

← PHOBOS SPACECRAFT
Painting: Michael Carroll



MARS SAMPLE RETURN ↓
Painting: William K. Hartmann

↑ NASA'S MARS OBSERVER
Painting: JPL/NASA

◁ SEARCHING FOR WATER

The next mission to Mars will be the United States' Mars Observer, scheduled for launch in 1990. This low-cost, special purpose spacecraft will carry a limited number of experiments to determine geochemical composition and climatological conditions — especially the presence of water. (See page 21 for a list of instruments.) A television imaging system is tentatively planned to obtain very high-resolution images of the martian surface.

The next planetary mission, after *Phobos* and the Mars Observer, is not yet approved. This is *Vesta*, another Intercosmos mission, planned to launch in the early 1990s. This mission's program has not yet been determined, but one of the goals will likely be further investigation of Mars. Additional targets are being considered. Several options are being studied, including penetrators (which the US has studied but never implemented), balloons or other atmospheric vehicles. A balloon might fly in the martian wind, or hover over possible sites for future landings.

EXPLORING THE SURFACE △

More speculative is the next step in exploration of the martian surface. Sample returns and rovers are the obvious successors to the *Viking* Landers. Samples must be returned to Earth for detailed studies, such as age-dating and geochemical analysis. Surface mobility will be needed — and can be provided by rovers — to gather samples from several different sites. Studies by NASA, the Jet Propulsion Laboratory and the National Academy of Sciences call for such a mission. In the Soviet Union, sample return and rover options are also being considered.

Several leading Soviet scientists have suggested that the best sample return/rover mission would be international, and include the United States. The US National Commission on Space has made a similar recommendation. The Planetary Society is advocating such a mission in 1996, as a precursor to human exploration of Mars. The Europeans and Japanese could also participate in the mission, making it a truly international effort.

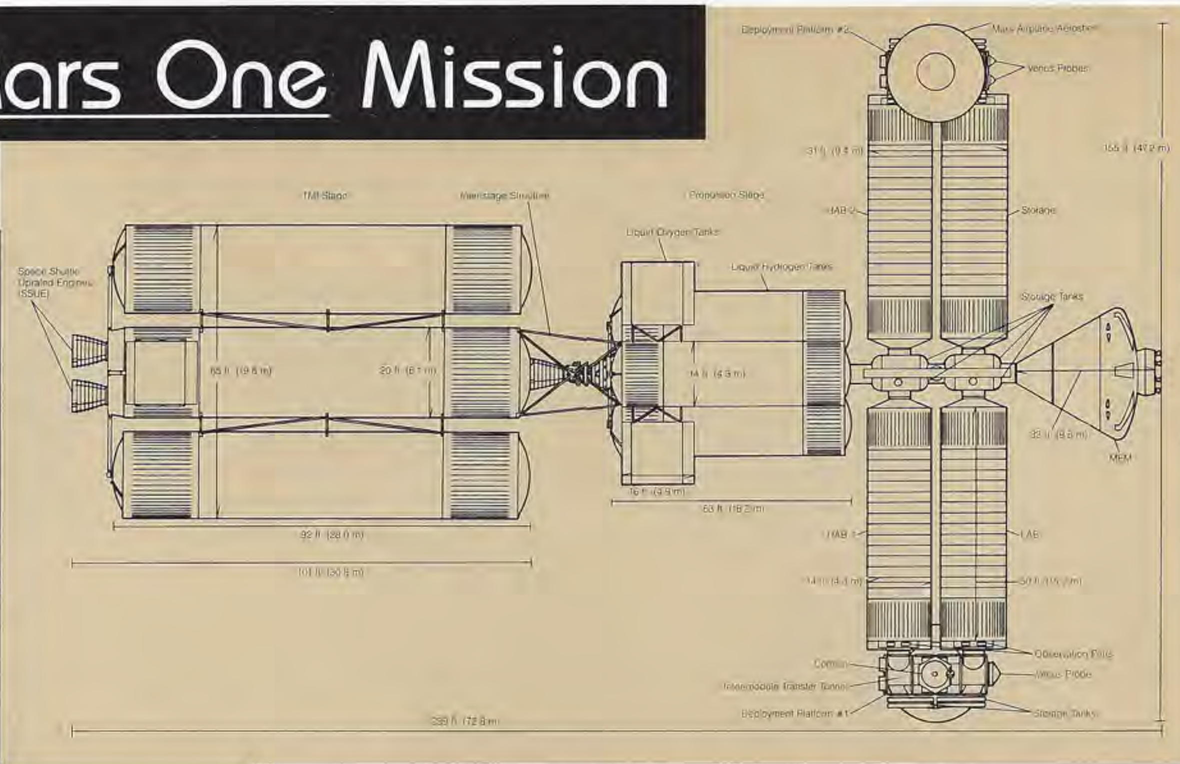
One possible scenario, first suggested by Academician Roald Sagdeev (a Planetary Society advisor) on a visit to the US, would be for one nation to undertake the rover mission, another the sample return, perhaps with the Europeans doing the orbiter. The only hardware interface would be on Mars when the rover delivers its samples to the return vehicle. In this way each nation would have a viable independent mission, but by working together the mission would be more productive.

The Mars One Mission

by Kerry Mark Joëls

It will certainly be among the most exciting 30 days in human history. Billions of our fellow humans will watch nightly newscasts and special live reports as 11 members of the international Mars One crew perform their experiments on and around the Red Planet. The Mars One scenario challenges us — it could be done in a decade!

The following are excerpts from the "crew manual" for the Mars One mission. These highlight what you might be doing if you were fortunate enough to be selected for the crew.



The Mars One Main Ship is a modular structure, consisting mostly of fuel tanks. The crew will ride in the habitability (HAB) modules, each 15.2 meters (50 feet) in length and 4.3 meters (14 feet) in diameter. Tunnels connect the HAB modules with the laboratory and storage modules, and with the Mars Excursion Module (MEM). Drawing: Paul Hudson

The Mission Begins

Your flight phase begins with the launch to orbit. You will be launched from the Kennedy Space Center on February 22, 1996. Your destination is the space station. Your initial job is to activate and check out main ship functions.

The *Mars One* ship is assembled in orbit. The support structures and modules are carefully moved together by assembly crews using Manned Maneuvering Units (MMU). Once the four modules are attached to the cross-shaped transfer tunnel system, the bracings are put in place. Fuel tanks and engines are then mounted in and on the support structure. Finally, the Mars Excursion Module (MEM) and the deployment platforms are mounted at the forward end and the tanks are fueled.

On March 7, 1996, the engines ignite and burn until you have accelerated from 28,160 kilometers per hour (kph), your orbital velocity, to 44,900 kph, your initial interplanetary cruise velocity.

You are settling into your rigorous training schedule, which continues uninterrupted for about 135 days. This schedule consists of special classes, which are loaded into the computers, videodiscs and on board hardware. These classes improve your mission and science skills through lessons, simulations and problem sessions in which you and your team members solve complex mission analysis problems. You also begin your physical conditioning regimen to minimize the deconditioning effects of weightlessness. By 30 days before Mars arrival, you are operating on an extremely busy work schedule and on sol-length days (one day on Mars equals 24.64 Earth hours).

On February 20, 1997, the ship performs a deceleration burn, which establishes orbit around Mars. The total stay at Mars is a compact 30 days (29.2 sols). This is the busiest and most difficult portion of the mission. Adherence to schedule is essential during this phase. While contingencies always arise, the schedule has been based on experience in lunar survey operations, space station operations and *Apollo* lunar exploration activities.

Orbital Science Activities

Obviously, the *Mars One* landing crew can explore only a small fraction of the martian surface. While the landing site was selected to provide the greatest possible information, there are other regions that must be explored. To do this, hardlanders and penetrators are stowed aboard. These devices deorbit and, targeted at deployment, crash-land at different sites around the planet. This procedure creates a global network of stations to study surface weather data and global seismic data (marsquakes).

The Mars Rover arrived at Mars January 11, 1997, 40 days (39 sols) ahead of you. After descent and landing, the Mars Rover (MR or Rover) was remotely guided on a traverse to within one-half kilometer of your expected landing site. Rover is made of two basic modules. The forward module is a sphere with a diameter of 3 meters (10 feet). The second module is a tanklike affair 2.1 meters (84 inches) in diameter.

Inside Rover is a driving station, a large storage closet, a narrow aisle in the second module with storage compartments and above them, two narrow berths with hammocks. Suits may be hung near the hatch or placed in the berths, depending on your activities. The inside is cramped, but you will be spending about six hours per day outside and eight hours sleeping.

Landing On Mars

To descend to the surface, the MEM is required. Like the Lunar Module of the *Apollo* program or the *Viking* Landers, the craft must land softly on the surface of the planet and then provide, like *Apollo*, life support and ascent from the surface back to an orbital rendezvous.

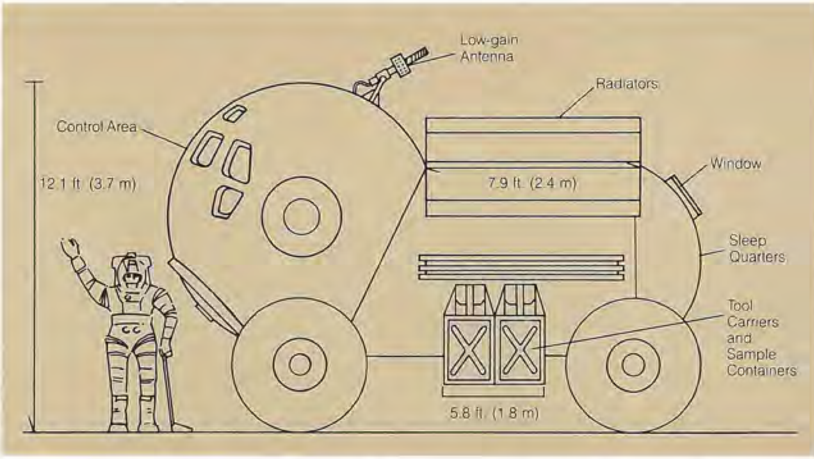
The MEM has both a descent and an ascent stage. Its overall shape is the familiar gumdrop of the old *Apollo* spacecraft. This insures a stable entry into the martian atmosphere. The crew compartment contains life-support equipment, a small galley, a small science lab, hammocks for sleeping and storage room for spacesuits.

Your primary landing site is on a mesa on the western side of Candor

Chasma (Shining Canyon). Candor Chasma is located around 6 degrees South, 73 degrees West, and is part of the Valles Marineris. Candor is the middle trough of three parallel canyons. Ophir Chasma is to the north of it and Melas Chasma is to the south. All these canyons are thought to have been formed as the plateau they are in cracked (faulted) and subsided. The walls of the canyon are composed of parallel layers. Following normal geologic theory, this would represent a layered history of events similar to the evolution of the Grand Canyon on Earth.

The mesa in Candor stands about 1.3 kilometers (0.8 miles) above the canyon floor. The temperatures on the top of the mesa indicate a smooth surface that might be fine grained and have few rocks. The mesa walls slope downward, revealing light and dark layers that should tell the story of what went on during the history of the valley formation. Studies of these layers will allow you to detect whether any water events occurred, and if any organics ever existed.

Only careful sampling, analysis and dating of these layers can finally answer the question of martian valley formation. But these findings will have far greater meaning. By traversing the canyon you can later actually date, using radioactivity, sequences of volcanic rocks to give a volcanic history of the region. This chemical analysis will give a history of rock formation under the martian crust over time and an idea of the eruption sequences in martian history. You may also find clues to the events that formed the martian channel system in the soils of the valley, and the chemical changes caused by water and climate. You may even find traces of solar activity embedded in the rocks. Coupled with lunar data, this will give more information on the past behavior of the Sun, its variation and its effects on Mars.



The Mars Rover is an electric-powered vehicle designed to support a small crew during the long traverse of the martian surface. Like a "recreational vehicle," it provides both transportation and shelter.

Drawing: Mike Hinge. Design: Brand Norman Griffin

The Traverses

Having landed first, the Mars Rover is steered by remote control to within 1.6 kilometers (1 mile) of your landing site. This should take it on a journey of no more than 6.4 kilometers (4 miles), given the navigational accuracy we can achieve. During the drive, its cameras will give you your first look at the terrain on the mesa. You will also be able to evaluate the condition and performance of your Rover.

The plan calls for an extremely ambitious traverse of about 160 kilometers (100 miles). This plan is not without risks — if your vehicle were to break down on this traverse, you would not be able to walk back to the module. The Mars Rover, however, was designed to provide at least triple-redundant systems for virtually every major component, and can be easily repaired. The Mars Rover can also be used as an automated explorer to sample other terrain after you leave.

The long traverse is designed to take 19.5 sols. You must average 12 kilometers (7.5 miles) per day. This traverse permits a detailed sampling of the various layers in the mesa walls, some canyon floor areas, a dark deposit region, and a visit to the talus of canyon wall deposits. Optional branches can include a longer traverse westward across the canyon floor.

Your work on Candor mesa or on the long traverse involves the emplacement of certain surface experiments. You will first set up the Mars Science Station (MSS). This station consists of a central station and outlying experiments connected by cable. The complex of instruments should continue to relay information for years.

The Journey Home

You depart from the Mars surface on March 20, 1997 and ascend to MEM rendezvous orbit. After lift-off you pass through a vertical rise phase and arch-over and then orbital insertion. You then fly three braking maneuvers to adjust your orbit to the Main Ship orbit and dock.

Your mission is not over. In fact, your most challenging weeks and months are yet to come. It is important to get back into your exercise and living routines. Over the coming months your physical and emotional well-being will be as important as the samples and information you bring back with you.

On December 19, 1997, the shuttle orbiter is launched. After a resupply stop at the space station, it changes orbits, makes a rendezvous and docks with your ship. You transfer to the shuttle and take your place in the passenger transport module. Approximately 45 minutes later, the orbiter performs the deorbit burn and leaves orbit.

The heads of state of all participating nations and the Secretary General of the United Nations are scheduled to be on hand to greet you, to offer congratulations and to welcome you home. The date is December 21, 1997.

You blast off from Mars on March 20, 1997. After a year in transit, you stayed on the surface for only 30 days, and now face 9 more months of travel before you again walk on Earth. Drawing: Paul Hudson

Kerry Mark Joëls is the author of The Mars One Crew Manual, recently published by Ballantine Books and available from The Planetary Society.

News & Reviews

by Clark R. Chapman

Watching Halley's Comet this spring reminded us all that there is more to the universe than comets. There was certainly more to be seen in the nighttime sky. To be sure, in mid-March even the most casual pre-dawn observer south of 35 degrees latitude would have quickly noted Halley's Comet as a streak of light in the sky. But as tens of thousands of travelers returned from Australia, the Caribbean and the South Pacific, few could claim that they were bedazzled by the comet. Indeed, some second-timers struggled valiantly to see it at all, so they wouldn't have to return home and fib to their families and friends about seeing Halley twice in their lifetimes. On the Planetary Society cruise, a group of would-be Halley-watchers serenaded the dining Society lecturers (yours truly among them) with a variation of "Twinkle, Twinkle Little Star," which included the words "up above the world so high/the dimmest object in the sky . . . . "

Beyond the Fuzzball

No matter how dim the comet — and it was no dimmer than predicted — few comet hunters who turned their eyes heavenward failed to be impressed by the nighttime skies. We twentieth-century city-dwellers forget to look up, or see little if we do. Those who traveled south found themselves gazing into the core of our galaxy, with Halley's Comet's dim tail lost in the myriad of stars in our Milky Way galaxy.

Back home, we can gain yet another perspective on our place in the scheme of things by reading a brief modern view of astrophysics in the March-April *American Scientist*. As George Field propels us through the history of twentieth-century astrophysical thought, we can think back to the vastness of the firmament beyond our transient cometary visitor. Generations of human beings have marvelled at skies like these, yet the questions George Field says are answered, and those profundities we are still grappling with, tell us how much more sophisticated we have become in recent decades in trying to satisfy our wonder.

As Halley's Comet neared the meridian in April, morning skygazers noted a bright "star" gleaming redly near the eastern horizon. This summer, the Red Planet will pass closer to Earth than it has for 15 years. As Halley hype recedes into history, Mars beckons anew for our attention. Not only is The Planetary Society interested in Mars as a future destination, but the National Commission on Space is proposing that human adventurers set their sights on the Moon and Mars. A timely article for future generations of would-be travelers to Syrtis Major, Margaritifer Sinus and other faraway places is in the May *Scientific American*.

Robert Haberle has prepared a visitor's guide to the martian climate. It's very cold by earthly standards, and the air is extremely thin, but martian winds blow and storms pass through in familiar ways — some of the time. It turns out that weather on the Red Planet is both simpler and more complicated than on Earth. In his recap of modern scientific thought about the martian atmosphere, Haberle reminds us that the small size of Mars is as important as its distance from the Sun in rendering its climate cold and dry. The interplay of volcanism, one-plate crustal tectonics, duststorms, orbital eccentricities, summer ice caps of dry ice and many other purely martian phenomena combine to make Mars a place very different from Earth. But it was not always so — as the dry river valleys testify — and it is not certain how the planet's climate might evolve in the future.

At the peak of Halley's Comet excitement, the National Aeronautics and Space Administration announced its selection of a spacecraft and a scientific team to accomplish the United States' next, and rather modest, exploration of Mars. The small, inexpensive mission called Mars Observer could be launched by 1990, if NASA's launch capability gets back in shape. It is intended to accomplish some important scientific investigations of Mars that somehow never got done during earlier, more elaborate missions.

Spacecraft Studies Continue

Scientific magazines continue to report on new results from deep space. The first official scientific reports about the historic Uranus encounter should be out by the time you read this, although I have heard that *Science* magazine forced *Voyager* scientists to cut back on the length and depth of analyses relative to those printed following past encounters.

Scientific reports of some earlier spacecraft encounters appeared in *Science* earlier this spring. In the March 21st issue, Soviet, French and American scientists report on the winds of Venus, as measured by two balloons dropped into the planet's atmosphere from the Soviet *Vega* spacecraft while they were en route to Halley's Comet. Scientists were surprised by the vertical motions measured during the balloons' two-day-long flights in the atmosphere. Some even more technical articles in the April 18th *Science* report on last summer's intercept of Comet Giacobini-Zinner by the rerouted International Cometary Explorer (ICE) spacecraft. (See the May/June 1986 *Planetary Report.*)

These scientific reports reflect several trends in modern spacecraft studies of the solar system: the continuing successes by older, rerouted spacecraft and the increasing fraction of new results being accomplished by international groups, chiefly Soviets and Europeans. Despairingly, we watch as NASA fails to launch even a simple geostationary satellite to keep tabs on our own weather. And we hope that there will soon be sufficient wisdom, resolve and funding to get the bold American exploration program back on track.

An Explanation and Rationalization

My attentive readers may recall my promise last winter to observe Halley's Comet from the darkest possible skies near my home in Arizona and *not* to venture forth on a cruise. As mentioned above, I was indeed seduced to join the *M/S Vistafjord*'s return from Rio. Shamelessly, I admit to having enjoyed every minute of it (including listening to the tales from 1910 by the second-timers aboard), and I gained only four pounds. But the truth remains that my best view of the comet was had in mid-March from dark skies near my home in Tucson, Arizona.

Clark Chapman, a much-traveled planetary scientist, is the author of Planets of Rock and Ice.

SOCIETY NOTES

LIBRARY OUTREACH

Look for *The Planetary Report* when you visit your community or school library! Thanks to a grant from member Nick Pavlica of Nevada, the Society was able to give one-year subscriptions to selected libraries throughout the United States. As we go to press, more than 1,000 libraries are participating in the program.

Because *The Planetary Report* can now be found in so many libraries, we are better able to accomplish one of our major missions: educating the public about space science and exploration. Library patrons will have ready access to *The Report* and the Society will be known to more people.

Most participants in the Library Outreach are school or small community libraries. Many librarians wrote to thank us for the gift subscription. Eric Schreur of the Hans Baldauf Planetarium in Kalamazoo, Michigan, wrote: "Working in the planetarium, I find *The Planetary Report* to be a valuable resource for ideas that result in interesting programs."

According to Jane McFarland, Acting Director of the Chattanooga-Hamilton County Bicentennial Library in Tennessee, "There is much interest in this publication and we are delighted to be able to make it available to the community." Alice Zacherl, Director of the Library Learning Resource Center of Palm Beach Junior College North, Florida, wrote that her library "is at a small branch campus and funds are never adequate for the periodicals that should support the instructional program. Hence, we are most appreciative of this fine publication in the field of science and technology."

NEW MILLENNIUM COMMITTEE EXPANDS

We are delighted to welcome two new members to the Society's New Millennium Committee. The committee is comprised of people whose special contributions significantly help the Society fund projects that will extend into the 21st century.

New member Dr. Sam Karayusuf wants his donation to be used "for the general purpose of sparking the public's imagination for planetary exploration." David Steinbuhler directed his contribution toward the Society's Search for Extraterrestrial Intelligence (SETI) program. We thank these two new members for their generosity.

The New Millennium Committee has given more than $150,000 to Society projects. These contributions are an important funding source for scholarships and new areas of research, and augment general membership contributions to these projects.

Committee members are: David Brown of Houston, Chairman; Polly Brooks, Phoenix; Sandra Rometsch, Houston; Richard Weisman, New York; Joseph Bosworth, Golden, Colorado; Sidney Newman, Houston; Steven Spielberg, Los Angeles; and the two new members.

Society members interested in joining the New Millennium Committee can get more information by writing to its chairman, David Brown, at the Society office, 65 N. Catalina Avenue, Pasadena, CA 91106.

MATSUNAGA CITES SOCIETY

Senator Spark Matsunaga (D-HI) recently honored The Planetary Society in the March 27, 1986 *Congressional Record*. In a speech to the Senate, he praised the work of Society President Carl Sagan and called him "a model for young scientists."

Senator Matsunaga also described his pride at being a Society member and said that the Society's activities and programs are "always in the service of the great democratic ideal of making complex issues accessible to the general public." He added, "some call it popularization, I call it democratization, and I hail it as a fundamental necessity for the healthy evolution of a democratic society. To the extent that scientists communicate with the public and vice versa, democratic values and institutions prosper." Dr. Sagan's article for *Parade* magazine, "Let's Go to Mars Together" (see pages 8-9), was also included in the *Congressional Record*.

Senator Matsunaga has been an effective advocate of international cooperation in space exploration. He was the chief sponsor of a resolution urging renegotiation of the US-USSR treaty on space exploration, later signed by President Reagan. Senator Matsunaga also authored the proposal for the International Space Year.

The Mars Project, the senator's recent book, discusses possibilities for Mars exploration and how it could be an international effort jointly led by the United States and the Soviet Union. *The Mars Project* is available through The Planetary Society (see page 23).

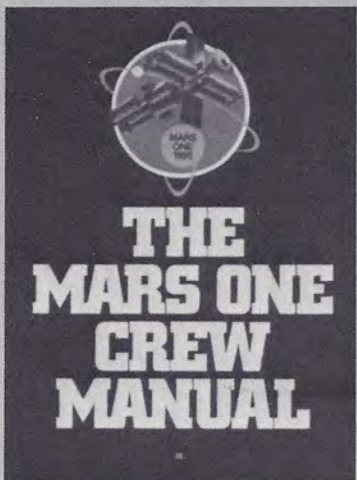
RECRUIT YOUR FRIENDS

If your friends and relatives are interested in joining The Planetary Society but haven't gotten around to it, here's your chance to recruit them. We now have membership application cards available for members who want to help the Society grow. Remember, there is strength in numbers — as our membership grows, so does our power to reach our goals. To receive a small stack of application cards, write: The Planetary Society, Communications Dept., 65 N. Catalina Avenue, Pasadena, CA 91106.

In April, NASA announced the instruments selected to fly on the Mars Observer, scheduled for launch in 1990 between two ambitious Soviet Mars missions: *Phobos* and *Vesta*. This spacecraft will be the first in a proposed series of Planetary Observers, low-cost missions based on Earth-orbiting spacecraft. As expected, the spacecraft will carry a gamma ray spectrometer, a radar altimeter, a pressure modulation infrared radiometer, a magnetometer, radio science, a thermal emission spectrometer and a visual infrared mapping spectrometer to study the planet, its composition and climate. But to the surprise and delight of many, the mission may also include an imaging experiment, the Mars Observer camera, capable of resolving surface details as small as a few meters. With such resolution, the Mars Observer could pick out the *Viking* Landers on the surface.

This imaging system will be extremely important in finding sites for future robotic and human exploration of Mars. If the experiment passes the final design review, it will be a valuable contribution to planetary exploration.

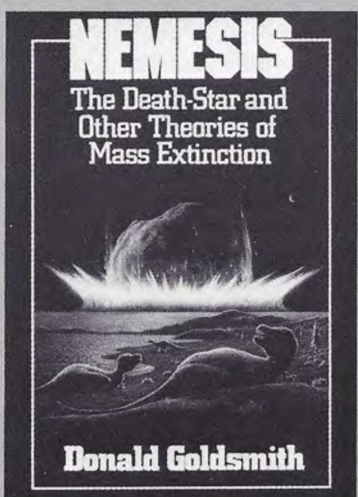
New Offerings!



THE MARS ONE CREW MANUAL

(#123)

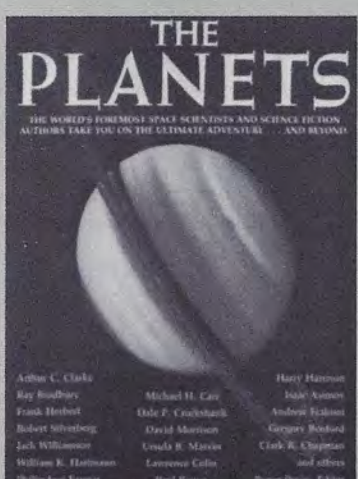
The year is 1995 and you are one of eleven people chosen to make the first trip to Mars. This is your complete training and operating manual. Inside you'll find a detailed description of your equipment, a full topographic map of Mars' surface and hundreds of charts, diagrams and illustrations. *The* Mars One *Crew Manual* is a concise and believable guide to all aspects of a trip to Mars. The facts and figures presented by author Kerry Joëls show that such a mission is entirely possible within the next ten years.



NEMESIS — THE DEATH STAR AND OTHER THEORIES OF MASS EXTINCTION by Donald Goldsmith

(#245)

What killed the dinosaurs? Does a "death star" periodically hurl comets into our solar system, causing mass extinctions? Astronomer Donald Goldsmith thoroughly examines the conflicting and controversial theories on what causes mass extinctions on Earth. *Nemesis* will bring you up to date on this exciting scientific debate.



THE PLANETS

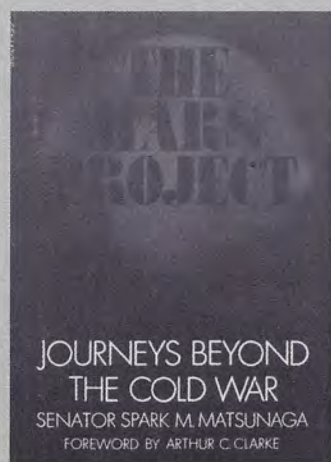
(#119)

Scientific essays, speculative fiction and breathtaking illustrations combine in *The Planets*, giving you a fun, absorbing look at our solar system. The fact-based essays are informative and thought-provoking complements to fascinating science fiction culled from many of the field's most imaginative authors. Every planet is spotlighted in order of its placement around the Sun.

PIONEERING THE SPACE FRONTIER

(#103)

What is the next step into space for the United States? Will we return to the Moon? Or will we set our sights on a more distant ând difficult goal — Mars? In this final report, the National Commission on Space charts a bold and pioneering course to the future and sets forth its "rationale for exploring and settling the solar system." The report is brightly illustrated with both photographs and paintings of our past and future in space.



THE MARS PROJECT — JOURNEYS BEYOND THE COLD WAR by Senator Spark M. Matsunaga

(#127)

This timely and important book for future space exploration is a collection of Senator Spark Matsunaga's proposals to Congress and the President; they range from the International Space Year to carefully thought-out ways to work with the Soviet Union on a manned Mars mission. This statesman's concepts provide hope that it is possible to explore the heavens in peace.

PHOTOGRAPHIC PRINTS

ENCOUNTER WITH URANUS

(#270)

As it flew by Uranus, *Voyager 2* returned striking and detailed images of that distant planetary system. This package of four pictures includes the dark, thin ring system; the muted blue-green atmosphere; a mosaic of the fascinating moon, Miranda; and a dramatic crescent of the planet, taken as the spacecraft headed out to its next target, Neptune.

ENCOUNTER WITH HALLEY'S COMET

(#271)

Finally, after thousands of years of watching, humans have seen the nucleus of Halley's Comet. The best views of the nucleus make up this set of two color pictures, one taken by the European Space Agency's *Giotto*, the other by Intercosmos' *Vega 2*.

Order Form

ORDER NUMBER	Books	PRICE (IN US DOLLARS)
101	**Voyage to Jupiter** by David Morrison and Jane Samz. 199 pages.	$11.00
103	**Pioneering the Space Frontier** by the National Commission on Space. 211 pages. NEW	$13.00
104	**Comet! The Story Behind Halley's Comet** by Greg Walz-Chojnacki. 64 pages. CLEARANCE PRICE	$ 8.50
105	**The Case for Mars** edited by Penelope J. Boston. 314 pages. Soft Cover	$18.00
106	**Mission to Mars** by James Oberg. 221 pages. Soft Cover	$ 6.00
107	**Out of the Cradle: Exploring the Frontiers Beyond Earth** by William K. Hartmann, Ron Miller and Pamela Lee. 190 pages. Soft Cover	$11.00
108	**The Case for Mars II** edited by Christopher P. McKay. 700 pages. Soft Cover	$27.00
109	**The Surface of Mars** by Michael Carr. 232 pages.	$15.00
110	**Imaging Saturn** by Henry S.F. Cooper, Jr. 210 pages.	$13.00
111	**Voyages to Saturn** by David Morrison. 227 pages.	$14.00
113	**The New Solar System** edited by J. Kelly Beatty, Brian O'Leary, and Andrew Chaikin. 240 pages. 2nd Edition	$12.50
117	**The Grand Tour: A Traveler's Guide to the Solar System** by Ron Miller and William K. Hartmann. 192 pages.	$ 9.00
119	**The Planets** edited by Byron Preiss. 336 pages. NEW	$22.00
123	**The Mars One Crew Manual** by Kerry Mark Joëls. 156 pages. NEW	$10.00
127	**The Mars Project** by Senator Spark Matsunaga. 215 pages. NEW	$16.00
131	**Earth Watch** by Charles Sheffield. 160 pages.	$20.00
134	**Rings — Discoveries from Galileo to Voyager** by James Elliot and Richard Kerr. 209 pages.	$16.00
135	**Atlas of the Solar System** by Patrick Moore and Garry Hunt. 464 pages. Soft Cover	$20.00
138	**The Comet and You** by E.C. Krupp, Illustrated by Robin Rector Krupp. 48 pages. CLEARANCE PRICE	$10.00
139	**The Return of the Comet** by Dennis Schatz, Design and Illustration by Yasu Osawa. 42 pages. CLEARANCE PRICE	$ 6.00
140	**Comet** by Carl Sagan and Ann Druyan. 398 pages.	$21.00
143	**Comet Halley – Once in a Lifetime** by Mark Littman and Donald K. Yeomans. 175 pages. CLEARANCE PRICE	$10.50
144	**Voyager: The Story of a Space Mission** by Margaret Poynter and Arthur C. Lane. 152 pages.	$ 8.50
145	**Cosmic Quest: Searching for Intelligent Life Among the Stars** by Margaret Poynter and Michael J. Klein. 124 pages.	$ 9.00
245	**Nemesis: The Death-Star and Other Theories of Mass Extinction** by Donald Goldsmith. 166 pages.	$14.00

For a written description of each item, see back issues of THE PLANETARY REPORT or write to The Planetary Society.

ORDER NUMBER	Other Items	PRICE (IN US DOLLARS)
148	**Human in Space** photograph of astronaut in space (16" x 20" Laser Print)	$ 8.00
149	**Earthrise** photograph of Earth from the Moon (16" x 20" Laser Print)	$ 8.00
151	**Apollo** photograph of Earth – full disk (16" x 20" Laser Print)	$ 8.00
152	**Comet Halley** (16" x 20" Laser Print) CLEARANCE PRICE	$ 7.00
153	**Earthprint** photograph of North America (8" x 10" Laser Print)	$ 4.00
155	**Voyager 1 at Saturn** (set of five posters)	$16.00
157	**Planetfest '81** – Saturn and the F-ring (Two 23" x 35" posters)	$ 5.00
159	**You Are Here** (23" x 29" poster)	$ 5.00
161	**Other Worlds** (23" x 35" poster)	$ 7.00
163	**Chesley Bonestell's Vision of Space** (40 slides with sound cassette)	$15.00
164	**Comets and Comet Halley** (30 slides with booklet) CLEARANCE PRICE	$21.50
165	**Voyager 1 Saturn Encounter** (40 slides with sound cassette)	$15.00
167	**Voyager 2 Saturn Encounter** (40 slides with sound cassette)	$15.00
169	**Voyager 1 & 2 at Jupiter** (40 slides with sound cassette)	$15.00
171	**Viking 1 & 2 at Mars** (40 slides with sound cassette)	$15.00
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