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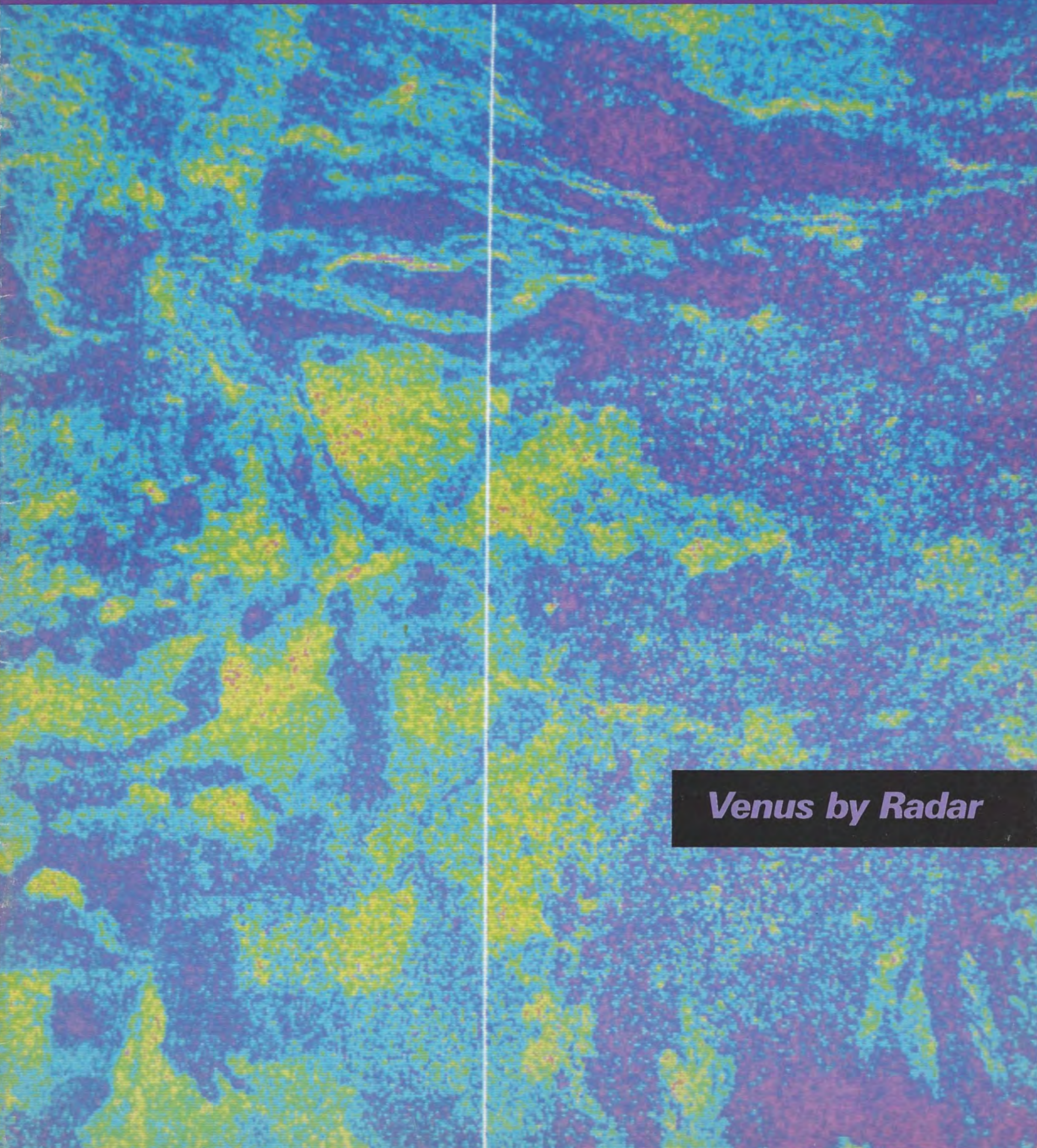

Venus by Radar

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COVER: The thick, sulfuric-acid clouds of Venus hide its surface from conventional imaging techniques. Scientists have turned to cloud-piercing radar to "see" through to the surface. Soviet Venera and US Pioneer orbiters returned radar data that scientists have compiled into images and maps of the planet's surface. Earth-based radar systems, such as the Arecibo Radio Telescope in Puerto Rico, can also be used to study Venus. Here is an Arecibo image of a region southeast of Lakshmi Planum in the northern hemisphere. Purples and blues represent smooth areas, while greens and yellows are rougher areas. *Image: Donald Campbell, Arecibo Observatory and Paul Fisher, Brown University*

Planetary Society Scholarship Winners Announced

The Planetary Society has chosen six high school seniors to receive its New Millennium Committee scholarships for 1986. The top winner is William Bies of Pittsburgh, Pennsylvania, who will receive $2,000 to aid his college education. The committee is also awarding $500 scholarships to: Katie Blum of San Anselmo, California; Colin Howell of Cypress, California; Marcin Taraszkiewicz of La Grange Park, Illinois; and Eric Tilenius of Huntington Station, New York. Douglas O'Neal of Hurricane, W. Virginia is a double scholarship winner this year; he won the Planetary Society Merit Scholarship in the National Merit Scholarship program and he will receive $250 from the New Millennium Committee program.

Each year The Planetary Society sponsors two sets of scholarships, one funded by the Society's New Millennium Committee and one administered by the National Merit Scholarship Corporation. The scholarships go to students of exceptional achievement and promise who plan careers related to planetary science.

Here we reprint the essay of this year's top winner, William Bies:

IN THE FIRST MONTHS OF THIS SUMMER, the planet Mars, approaching opposition, shines brightly in the southeastern sky, beckoning us as it did Percival Lowell almost a hundred years ago. During the present hiatus in the American space program, it shines as a symbol of hope for renewed accomplishments in the future. But before we make any observations about that future, it is well to begin with an explanation of my generation's experience with outer space.

When I was young, space exploration was the established order of things. The *Apollo* landings and *Skylab* were accomplished facts, and, in the era of *Mariner* probes, *Viking*, *Pioneer* and *Voyager*, planetary exploration was in its heyday. Yet in the following years, it seemed the promise of the future was lost. Year after year brought further cuts and delays in space projects, and the shuttle program moved forward only haltingly. The notable absence of an American probe at Halley's Comet underscores this lack of commitment. Behind all the present administration's rhetoric — promises of the much-delayed space station and space commercialization — the problem is not that of manned versus unmanned, but simply that the nation's decision makers fail to see the value of a vigorous space program.

We live in an era with a technological solution for anything, from the Strategic Defense Initiative to cancer research, yet the old problems of war and economic insecurity continue to plague us. The Cold War flashes on and off again. As a culture we are preoccupied with the search for material happiness. Twentieth-century man has lost the power to act, and to believe; we are indifferent, without a clear sense of direction. It is not surprising that the space program should reflect a lack of direction.

In the aftermath of the *Challenger* accident, it is time for us to re-examine our space policy. Mars enters the scene here, because it can serve as the focal point of a true international space program, which could provide much-needed unity and direction of mankind's efforts in outer space. A joint unmanned survey of Mars, perhaps including a sample-return mission or a surface rover, will be followed by a manned mission. When we go to Mars, it will not be national rivalry, but international cooperation that takes us there.

And when we arrive, we will be there to stay, for we have much to learn from Mars. The probes already sent to Mars and Venus have opened up the field of comparative planetary science, particularly in meteorology. The source of Mars' periodic changes in climate, the possibility of life, either now or in a previous epoch, and the surface composition and history, all remain to be investigated. We can make plans to colonize Mars, and perhaps, assuming that mankind decides that planetary surfaces are the best place to locate an expanding civilization, Mars will become our first terraformed planet.

In the immediate future, Mars exploration should serve as part of an overall international effort in space exploration, which would include planetary probes, a lunar outpost and an asteroid-return mission to assist in the founding of a permanent spacefaring civilization. All nations will realize the technological and scientific rewards of such an endeavor. We can hope that economic dependence arising from an expanding space-based industry will lead to political dependence, and economic unity eventually to political unity. □

A Talk with
Thomas O. Paine

Dr. Thomas O. Paine, Chairman of the President's National Commission on Space, has joined The Planetary Society's Board of Directors. As a Director, Dr. Paine will help set policy to shape the Society's future. At this time of crisis in American space exploration, the Society hopes to play an important role in helping to establish new goals for NASA, and Dr. Paine's advice and experience will be a major new resource for us.

Dr. Paine knows the US space program well. He served as Administrator of NASA from October 1968 to July 1970, and oversaw the first manned flights of* Apollo *and the historic first landing of humans on the Moon. During his tenure, the* Viking *and* Voyager *expeditions to the outer solar system were initiated; Paine advocated a continuing program of lunar exploration, construction of an Earth-orbital space station, and human planetary missions, specifically a trip to Mars.

In 1949, Dr. Paine received a Ph.D. in physical metallurgy from Stanford University. He came to NASA after 25 years with General Electric. As manager of TEMPO, GE's long-range planning and interdisciplinary "think tank," Dr. Paine made a reputation as a productive and innovative scientist-executive. After leaving NASA, he served as President, Chief Operating Officer and as a director of the Northrop Corporation. He is now Chairman of Thomas Paine Associates, a high technology consulting firm.

Society President Carl Sagan commented, "Tom is that rarest of blends, a practical visionary. As a former chief executive officer of a major aerospace corporation, and as a former NASA Administrator, he knows intimately both the theory and practice of spaceflight technology; but in his writings on the human future on Mars and in the extraordinarily forward-looking report of the President's National Commission on Space (the Paine Commission), he reveals an ability to envision the future of Earth and the solar system on a very grand scale. We are delighted that he is joining the Board of Directors of The Planetary Society."

Our Executive Director, Dr. Louis D. Friedman, talked with Dr. Paine in his Westwood, California office.

Louis Friedman: *After serving for a year as Chairman of the National Commission on Space, talking to people throughout the country, what is your impression of what the people want the United States to do in space?*

Thomas Paine: There is tremendous grass-roots enthusiasm for space as an exciting new theater that the United States should enter. This is combined with a puzzled feeling that somehow there is no leadership, no vision. People don't know where America should be going. But wherever it is, they surely wish we were getting at it.

They inspired us on the commission to set down where we think the United States should be leading in space over the next 50 years. The public wants to know where we are going, when we will get there, what we have to do, how much it will cost, what opportunities will there be, what exciting scientific questions will we answer, what unknowns will challenge us — and if we can do this by working with other people on the planet.

There is an enormous feeling that space exploration is inherently a global effort and that we need politicians not only with a broad national vision, but also with a vision of how the people of the planet can work together. I tremendously admire what the medical profession has done in the conquest of smallpox. They simultaneously elimi- →

nated the smallpox virus over the entire globe. There is now no threat of smallpox left on the planet.

The medical profession has shown how we can mount global efforts. We in planetary exploration have an even greater opportunity. We will always have a lot of effort organized nationally, and that's fine. We organize the Olympic Games on a national basis, nevertheless the games themselves are international. We need to find some new institutions, new ways of approaching this, and I hope The Planetary Society will play a vigorous role.

But there are dangers as well as opportunities here. The danger is that we wind up in a hands-across-the-sea series of ineffectual meetings in which we all compliment one another on our broad international visions and nothing happens. We've got to find effective ways to apply modern technology globally to the expansion of our species beyond our home planet, with all the research, engineering and exploration that implies.

LF: *What are the highlights of the report?*

TP: Back in 1961 when the American space program was in shambles after many failures, President John Kennedy put our sights on the Moon. That single purpose allowed us to develop the capabilities to put man on another world. That decision created the space program that put the United States in the leadership position that Kennedy felt we needed.

His decision was sensible in that era. To repeat that program today would be all wrong. We've gone beyond that. The commission recommends three basic things: 1) Physical exploration and basic science; 2) Applied research leading to the settlement of the solar system; 3) Economic return.

These three themes, all of equal value, have to be embedded in any successful space program. We've got to develop the technology to increase our effectiveness and decrease the cost of operations in space. We've got to develop a far cheaper access to space with post-shuttle launch systems.

A New Long-Range Civilian Space Program

***Appointed by President Reagan and chaired by Dr. Thomas O. Paine, the National Commission on Space was instructed to develop an agenda for the United States to follow over the next 50 years in its exploration of space. These are the commission's primary recommendations adapted from their report,* Pioneering the Space Frontier.**

The National Commission on Space proposes a future-oriented civilian space agenda with three mutually supportive thrusts: 1) Advancing our understanding of our planet, our solar system and the universe; 2) Exploring, prospecting and settling the solar system; and 3) Stimulating space enterprises for the direct benefit of the people on Earth. We judge these three thrusts to be of comparable importance.

To accomplish them economically, the nation must make a long-range commitment to two additional thrusts: 1) Advancing technology across a broad spectrum to assure timely availability of critical capabilities; and 2) Creating and operating systems and institutions to provide low-cost access to the space frontier.

A Logical Approach

To meet the challenge of the space frontier, the commission proposes a sustained step-by-step program to open the inner solar system for exploration, basic and applied research, resource development and human operations. This program will require a creative partnership of government, industry and academia of the type that has proved highly productive in previous national enterprises. US leadership will be based upon a reliable, affordable transportation system and a network of outposts in space. This infrastructure will allow us to extend scientific exploration and to begin the economic development of the vast region stretching from Earth orbit outward to the surface of our Moon, to Mars and its moons, and to accessible asteroids.

Advancing Science

The commission recommends: ○ A sustained program to understand the evolution of the universe; ○ A study of the evolution of the solar system; ○ A global study of planet Earth; ○ A study of the Sun and the vast region it influences; ○ A continuing program to search for evidence that life exists — or has existed — beyond Earth; ○ Provision of state-of-the-art facilities for laboratory experiments on the ground and on the space station; and ○ New research into the effects of different gravity levels on humans and other biological systems, as well as on processes in physics and chemistry.

Exploring, Prospecting and Settling the Solar System

The commission recommends: ○ Continuing robotic prospector missions of our Moon, Mars and its moons and accessible asteroids; ○ Missions to obtain samples from our Moon, Mars and its moons and the most accessible asteroids; ○ Robotic and human exploration and surveying of the Moon and Mars; and ○ Human outposts and bases in the inner solar system.

UPPER RIGHT: Two interplanetary transfer vehicles slow down by "aerobraking" (using the friction in the upper atmosphere) as they return to Earth. The spherical tanks hold propellant and the cylindrical module holds several human passengers. The aerobraking technique may be used in interplanetary travel to decrease fuel requirements. RIGHT: Sometime in the next century, humans may build settlements on Mars. The cost of such development is high, and it is likely that, when Mars is settled, it will be by a consortium of nations, including both the United States and the Soviet Union. *Paintings: Robert McCall*

It's important not to look at our report as a series of disconnected missions — take a picture of Io, bring back a sample of Triton. Each year we'll have greater capabilities. We recommend cumulatively building on the space frontier, and that is how the United States should be directing its investments.

LF: *Will the National Commission report be politically effective?*

TP: It's too early to say. The prospects are good, but we may or may not succeed. I feel that the report reflects basic realities, and whether we did the report in 1970, 1980 or 1990, in Washington, Moscow or Tokyo, we would have come up with the same report. It would be the same solar system, the same opportunities, the same technology, the same cost.

Our first hurdle, of course, is to get it accepted by the Reagan administration. But the presidential elections are coming up, and we then have to face a new administration. We hope that our report will not be a political football, but something that all forward-looking people can rally behind.

LF: *Is the United States a reluctant spacefaring nation?*

TP: No, not at all. The United States has been a very enthusiastic, innovative and determined spacefaring nation. Only twelve men have walked on another world, and almost the only thing they have in common is that they carry American passports.

LF: *But what about the scaling down of solar system exploration, the failure to send a spacecraft to Halley's Comet, the lead in Mars exploration passing to the Soviets?*

TP: The things you cite are more a loss of national leadership. When you say the United States, I think of 50 states and 250 million people. Frankly, the grass roots is way ahead of the Washington leadership in this area. If the Washington leadership were to explicitly say that, because of Gramm-Rudman and the nation's financial situation, we can no longer afford to lead in space, that we have decided to turn the leadership over to the Europeans, the Asians and the Soviets, then a cry would go up across our country that would blast them out of the water. It's a ridiculous statement. No one would ever say that.

Yet, that is precisely what Washington said when they cut NASA down to a third of the size it was during *Apollo*. We let other nations compete with us when they could not have if we had maintained our technological lead. This is where →

Space Enterprise

The commission recommends: That wherever possible the private sector be given the task of providing specified services or products in space, and be free to determine the most cost-effective ways to satisfy those requirements, consistent with evolving federal regulations. We also recommend that NASA initiate research and development now on systems and processes for application beyond low Earth orbit.

Building the Technology Base

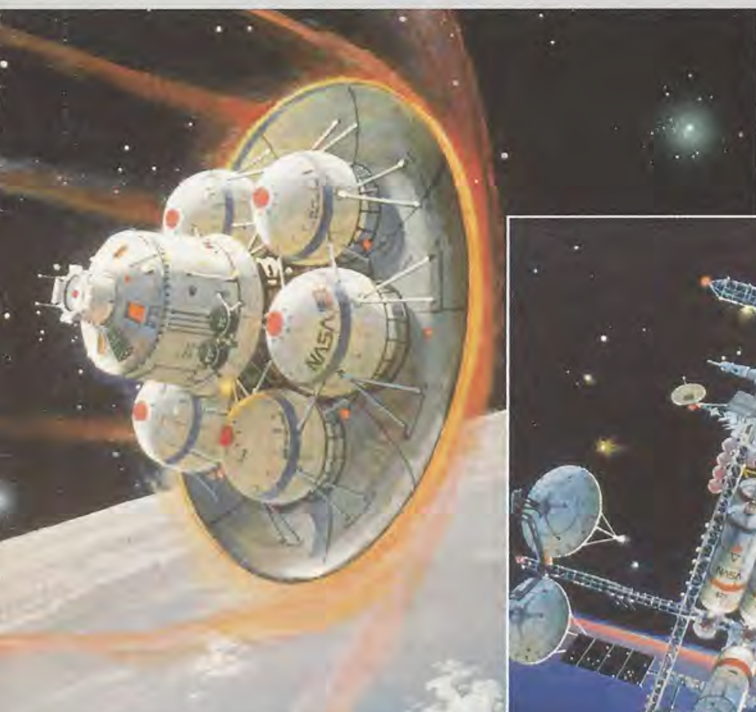
We recommend: A threefold growth in NASA's base technology budget, with special emphasis on intelligent autonomous systems. We recommend demonstration projects in seven critical technologies: 1) Flight research on aerospace plane propulsion and aerodynamics; 2) Advanced rocket vehicles; 3) Aerobraking for orbital transfer; 4) Long-duration closed ecosystems (including water, air and food); 5) Electric launch and propulsion systems; 6) Nuclear electric space power; and 7) Space tethers and artificial gravity.

International Cooperation and Competition

The commission recommends that: Vigorous steps be taken to attract other nations to work in partnership with us. We must mobilize this planet's most creative minds to help us achieve our challenging goals. All of humankind will benefit from cooperation on the space frontier.

Highway to Space

The commission recommends that: Three major space transportation needs be met in the next 15 years; the three major transport systems requirements are: 1) Cargo transport →



RIGHT: The future envisioned by the National Commission on Space includes large, Earth-orbiting "spaceports," an air-breathing aerospace plane and transfer vehicles shuttling regularly from the Moon to the spaceport. To achieve such a complex technological system in space early in the 21st century would require a large increase in the NASA budget.

The Planetary Society can make a real contribution — to warn the nation about the lack of vision and leadership.

LF: *Why did you join The Planetary Society's Board of Directors?*

TP: Joining The Planetary Society now is something like joining an "Americas Society" in 1492. The destiny of our nation and the destiny of our species lie out in the solar system. The Planetary Society is dedicated to research, to exploration and to the settlement of our solar system, and I want to be associated with that.

LF: *What would you like The Planetary Society to do?*

TP: We've got to become a little livelier, a little bolder, perhaps have some projects fail because we tried to do too much too soon. If we never fail, we're not moving fast enough. The Planetary Society can be out in front of NASA and lead where a government bureaucracy hasn't the liveliness to go.

We need to be working on the combination of men and machines and how each will be used to explore the solar system. What kind of power sources will we have? What extraterrestrial resources can we process? What will be the role of a human outpost — eventually a human settlement? Can we start agriculture without humans present? We should be extrapolating into the next century, relating it to the rest of American culture at that time.

The third area that needs attention is the search for extraterrestrial intelligence. You've done a wonderful job in that area and I would simply propose that we do the same job in the other two areas. All these things have equal priority in my mind.

Our fundamental growth is linked to the degree to which we catch the excitement of our members and the general public through our publications and programs. We must make them feel they want to belong to the Society because they share our aims. They will know the money they give us will be partly spent returning them their money's worth in services. □

to low Earth orbit; 2) Passenger transport to and from low Earth orbit; and 3) Round-trip transfer beyond low Earth orbit.

The commission supports a major national commitment to achieve early flight research with an experimental aerospace plane.

The commission recommends that: The US space station program be kept on schedule for an operational capability by 1994, without a crippling and expensive "stretch-out," and a space-based robotic transfer vehicle be developed to initiate a Bridge Between Worlds.

Bridge Between Worlds

To build the 21st-century Bridge Between Worlds that will open the solar system, the commission recommends: ○ Developing reliable high-performance electric propulsion systems; ○ Developing fully self-sustaining biospheres; and ○ Establishing initial outposts and bases on the Moon and Mars.

Long-term exponential growth into eventual permanent settlements should be the overarching goal.

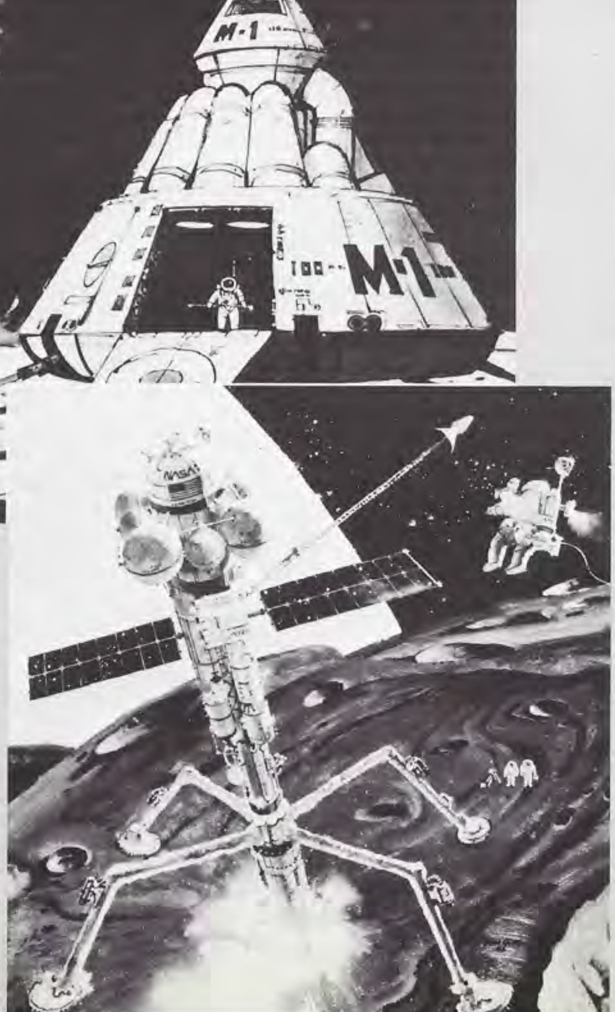
Twelve Technological Milestones in Space

A dozen challenging technological milestones would mark our progress: 1) Initial operation of a permanent space station; 2) Initial operation of dramatically lower-cost transport vehicles to and from low Earth orbit for cargo and passengers; 3) Addition of modular transfer vehicles capable of moving cargo and people from low Earth orbit to any destination in the inner solar system; 4) A spaceport in low Earth orbit; 5) Operation of an initial lunar outpost and pilot production of rocket propellant; 6) Initial operation of a nuclear electric vehicle for high-energy missions to the outer planets; 7) First shipment of shielding mass from the Moon; 8) Deployment of a spaceport in lunar orbit to support expanding human operations on the Moon; 9) Initial operation of an Earth-Mars transportation system for robotic precursor missions to Mars; 10) First flight of a cycling spaceship to open continuing passenger transport between Earth orbit and Mars orbit; 11) Human exploration and prospecting from astronaut outposts on Phobos, Deimos and Mars; and 12) Start-up of the first martian resource development base to provide oxygen, water, food, construction materials and rocket propellants.

Benefits

The new space program we propose for 21st-century America will return tangible benefits in three forms: 1) By "pulling-through" advances in science and technology of critical importance to the nation's future economic strength and national security; 2) By providing direct economic returns from new space-based enterprises that capitalize upon broad, low-cost access to space; and 3) By opening new worlds on the space frontier, with vast resources that can free humanity's aspirations from the limitations of our small planet of birth. □

This article is adapted from *Pioneering the Space Frontier: The Report of the National Commission on Space*, published by Bantam Books, © 1986. This report is available from The Planetary Society (see insert).



ABOVE: The first mission to Mars could be a "simple" affair, similar to the Apollo missions to the Moon. A rover could be sent down ahead of the human crew, to meet them when they land on Mars. Such a mission would be less expensive than the "Bridge Between Worlds" suggested by the National Commission, and still less if shared by several nations.

RIGHT: On their way to Mars, travelers may want to stop off at Phobos to refuel their spacecraft. The small martian moon may hold large reserves of hydrogen and oxygen, which, if mined responsibly, could be used to fuel interplanetary vehicles. Propellant mining could become the first industry on Phobos.

Paintings: Robert McCall

A Time To Act

An Editorial
by Louis Friedman

WASHINGTON, DC — "My fellow Americans, the United States has decided to relinquish its leadership role as a major spacefaring nation, and to leave to more vigorous peoples the risky and challenging task of exploring the solar system. Now that we've become the world's wealthiest, most technically advanced and most heavily armed nation, we feel that it's safe to sit back.

"Because we do wish to sponsor some space research we will modestly support the Soviets, the Europeans, the Japanese and others who plan to move into the forefront of space science and exploration. We will offer them small instruments which we hope they will carry on their spacecraft (provided that no US technology transfer is involved). We will not, however, initiate bold new forays into the unknown.

"We will try to provide our students with English translations of exciting discoveries made in Darmstadt, Moscow and Tokyo. This won't cost much, and will enable young Americans to learn about the new worlds and opportunities being developed by other nations."

These thoughts may not yet have been put into words by a Washington spokesman, but the attitude they represent is spreading. The United States is abandoning its historic leadership in the exploration of other worlds.

How Did We Get Here?

The problems with the space program did not begin with the *Challenger* accident. In fact, *Challenger* is more an effect than a cause of our crisis in space. The United States put all of its launch vehicle eggs into the unwoven shuttle basket. Missions were delayed and new opportunities lost; between 1975 and 1981, while the shuttle was being built, no new planetary missions were approved, save *Galileo*.

And what of that mission to the jovian system? *Galileo* was originally scheduled to be launched from a space shuttle in January, 1982. When the shuttle development fell behind schedule, the launch was delayed to March, 1984. Since the relative positions of the planets change annually, the spacecraft had to follow a higher-energy trajectory to Jupiter. Mission planners decided to split the spacecraft so that the Orbiter and Probe would be launched from the shuttle separately using the Inertial Upper Stage (IUS). The IUS was needed to send spacecraft from the low Earth orbit of the shuttle to interplanetary trajectories. Then poor performance and cost overruns led to the cancellation of the IUS program. As a result, *Galileo* was delayed to May, 1985 and returned to its original, one-spacecraft configuration using a *Centaur* upper stage.

When the Reagan administration came into office, the *Centaur* upper stage was cancelled for budgetary reasons, so the *Galileo* mission had to be redesigned yet again. The spacecraft would now follow a "delta-vega" trajectory, using extra propulsion and a gravity assist to loop around the inner solar system before reaching Jupiter two years later (see the March/April 1982 *Planetary Report*). Then Congress restored the *Centaur* to the budget, so *Galileo* was rescheduled for launch from the shuttle in May, 1986.

The *Challenger* accident delayed the mission again to either August or December, 1987. This had to be changed again, however, when safety concerns about *Centaur* pushed back the launch to December, 1988. Then, in June, the *Centaur* upper stage for the shuttle was cancelled once more; now *Galileo* cannot possibly be launched in 1988.

Where does *Galileo*, America's premier approved planetary mission, go from here? Four options remain: to wait for the Air Force to develop a new expendable *Titan/Centaur* launch vehicle, to ask some other nation to launch *Galileo*, to go back to the cancelled IUS, or to quit.

The approved US program for solar system exploration now looks like this:

Ulysses (the European Solar Polar mission), *Magellan* (the US Venus Radar Mapper), the Mars Observer, and *Galileo*, to be launched in this sequence:

☐ *Ulysses* — launch in 1989 to arrive over the Sun in 1995;
☐ *Magellan* — launch in 1989 or 1991 to arrive at Venus in 1990 or 1991;
☐ Mars Observer — launch in 1990 to arrive at Mars in 1991;
☐ *Galileo* — launch in 1991 to arrive at Jupiter in 1995.

Eleven years will have passed since the last launch of a US mission to the planets. During these 11 years the Soviet Union will have sent spacecraft to Venus, to Halley's Comet and to Mars. The Europeans and the Japanese have already launched their first interplanetary missions to Halley's Comet.

But this optimistic US schedule assumes no new budgetary limitations and no further cuts in NASA's space science budget from shuttle or space station expenditures. This is unlikely, since even now, NASA seems to be repeating history and putting all its eggs into the similarly unwoven space station basket. Furthermore, the available shuttle launches will be constrained by military and other priorities that will severely pressure the schedule.

We had hoped that the Comet Rendezvous Asteroid Flyby (CRAF) mission would be initiated in fiscal year 1988. The spacecraft could have reached its objectives before the end of the century. But based on budget plans for 1988 it now appears that there will be no new start for CRAF in this coming fiscal year.

The recent history of US planetary exploration suggests that the speech imagined above realistically reflects the de facto space policy of the United States.

Where Do We Go From Here?

More than a new launch vehicle, more than a replacement orbiter or a space station, even more than an increased budget, *NASA needs a new long-range goal.* Indecision, confusion, tragedy and lack of leadership have devastated the morale of America's once proud space program. NASA's sense of purpose has vanished. Crucial decisions about launch vehicles, shuttle orbiters, the space station and the budget are not being addressed coherently. Without vision, purpose and leadership, there can be no future; nothing can happen until our nation's leaders envision new goals and implement new plans.

What constitutes a reasonable long-range goal? The international exploration of Mars, culminating in a human mission in the early 21st century, would be ideal. It would restore NASA's morale and purpose, and attract the best people to the space program. This goal would define a purpose for the space station, so that its requirements, design and schedule could be sensibly, rather than arbitrarily, planned. It would provide a focus for planetary exploration, a focus which would guide precursor and supporting missions of science and technology — and not only to Mars. It would give spaceflight with human crews an objective, and restore humanity to one of its greatest roles: exploring the un-

(continued on page 15)

New Results from Venera 15 and

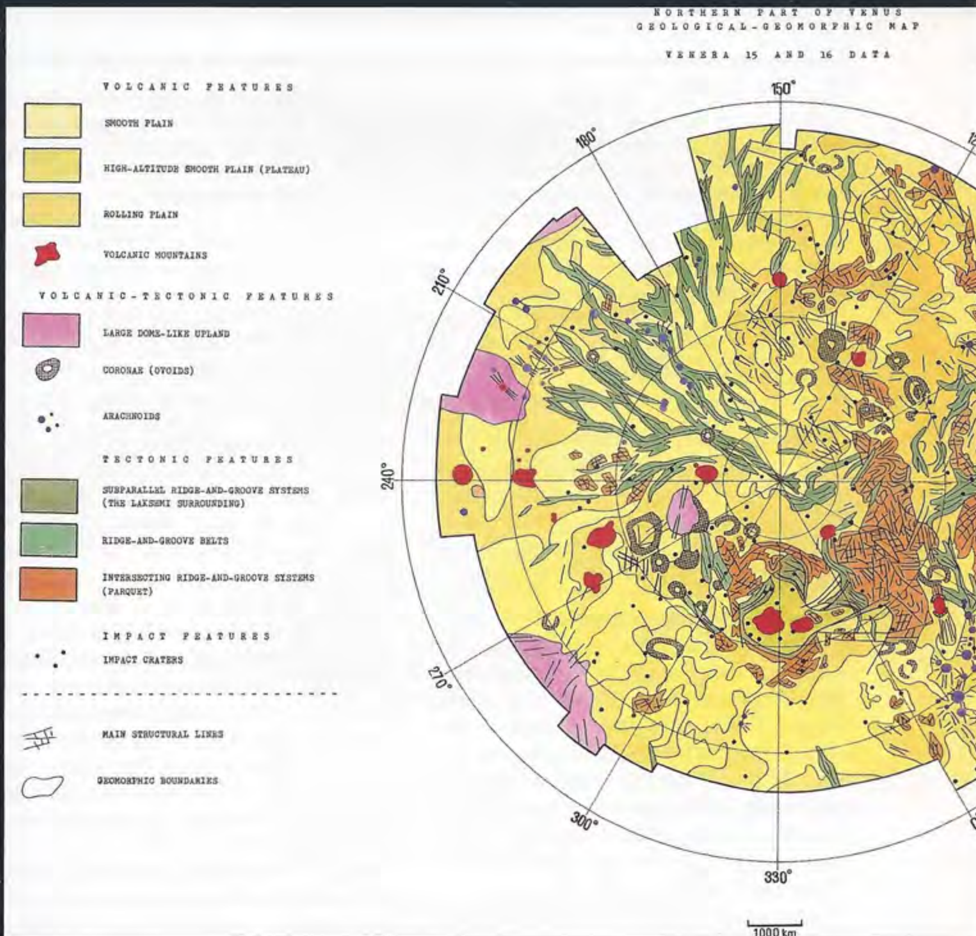
by N.A. Armand, V.L. Barsukov and A.T. Basilevsky

A geologic-morphologic map of the northern part of Venus surveyed by the Soviet Venera 15 and 16 radar mapping spacecraft was presented at the seventeenth Lunar and Planetary Conference in Houston last March. The map is based on the analysis of new computer-processed mosaics, such as the black and white images on the next page.

The main conclusions of the study are:

- ***Volcanism and horizontal movements of the planet's crust are mainly responsible for the observed geologic pattern.***
- ***Venus' tectonic style i.e., the response of its crust to internal motions, heating, and chemical and mineral transformations is different from both the Earth's and that of smaller planetary bodies, such as Mars, Mercury and the Moon.***
- ***The abundance of impact craters (formed by asteroids or comets falling on Venus) gives evidence that the average age of the terrain under study is about one billion years, so the volcanism and tectonism are not recent and weathering and other processes that would obliterate the craters are extremely slow.***

N.A. Armand is a radar specialist at the Soviet Academy of Sciences Institute of Radio Engineering and Electronics, V.L. Barsukov is the Director of the Vernadskiy Institute of Geochemistry & Analytical Chemistry in Moscow and A.T. Basilevsky is a planetary geologist and imaging radar analyst for the Vernadskiy Institute.



From October 1983 to July 1984, the Soviet Venera 15 and 16 used radar to map Venus from near-polar orbits. The radar im a picture of a planetary surface that has been subjected to stresse kinds: compression, extension and shear in various combinations. areas, the result is a folded or faulted belt of mountains and valley regions the plains are wrinkled into a crisscross "parquet" pattern tion to scattered impact craters, there are huge circular features c coronae, which may have been formed by plumes of hot magma ris the planet's interior.

— JAMES D. BURKE

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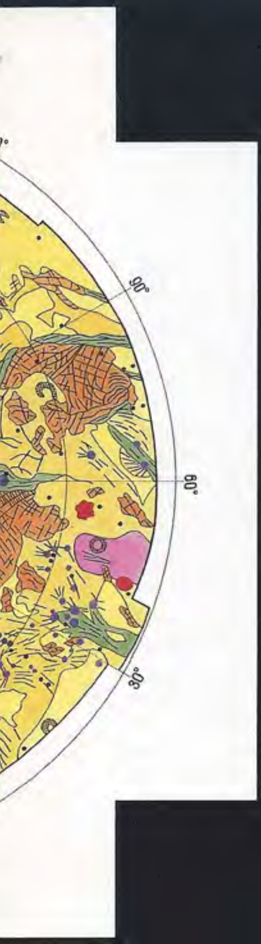

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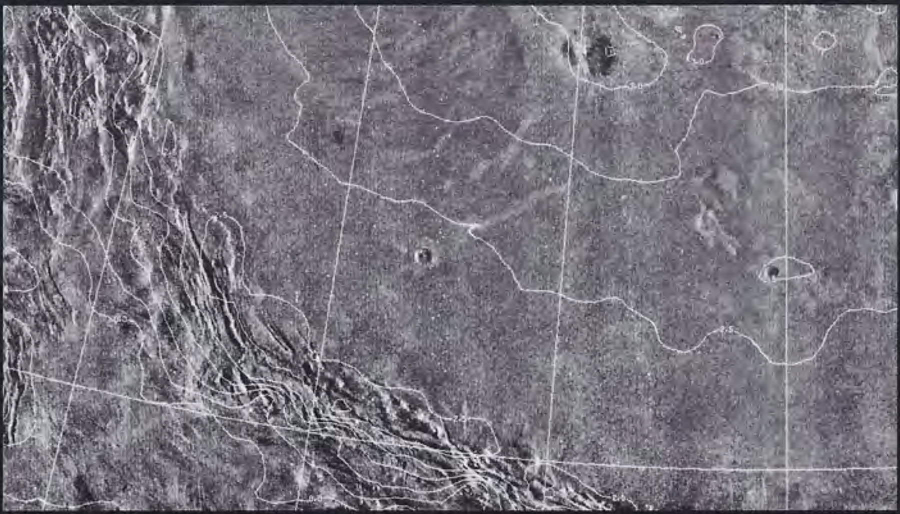
Shegurochka Plain is apparently a result of vast flooding by basaltic lavas similar to those in parts of the Earth and Moon. The patchy character of the plain is probably due to superposition of lava flows. Contour lines correspond to altitude above the nominal radius (6,051 kilometers from Venus' mass center). North is at the top in all images.



Southwest part of Lakshmi Plateau. A system of flow-like, radar-bright features can be seen on the plateau's surface; they are the solidified flows of basaltic lavas. Lying near the center of the picture is a central-peaked impact crater about 20 kilometers in diameter. Rough topography to the west and south of the plateau is a result of intensive tectonism.

Part of the Freyja Mountains bordering the northern part of Lakshmi Plateau. The mountains were formed by tectonic compressional deformations, wrinkling up as they were pushed together. In some aspects they resemble the folded mountain belts on Earth.

A complex system of intersecting ridges and grooves (so-called "parquet" terrain) was formed by horizontal tectonic deformation. Plain-forming materials (basaltic lavas) overlap low-altitude parts of the parquet.

News & Reviews

by Clark R. Chapman

Wonderful though *The Planetary Report* is for running thought-provoking, beautifully illustrated articles about the solar system and the conquest of the cosmos, there's a wealth of information elsewhere. In this column I usually dwell on issues raised by two or three articles published in other magazines. This time, however, we'll skim through a larger sampling, just to remind you that there are lots of publications that treat our subject. First, let me briefly note the loss of one of the best general science magazines, *Science '86*, which will soon cease publication.

Real Science

If you really want to dig into the technical details of what scientists are learning about the planets, you have to read journals like *Icarus, The Astrophysical Journal, The Journal of Geophysical Research*, and other professional journals. They are hard to find, and difficult to understand once found, even by scientists themselves. (Although scientists vainly hope their papers will be read by thousands, most are lucky if their own graduate students and one or two colleagues ever read them carefully.)

Science and *Nature* are more accessible journals of this sort. These weekly magazines may be in your library, and the scientific reports are short though hardly less technical than in *Icarus*. The papers that appear in these magazines are usually important and timely, if not always "right." The best recent examples are well worth looking at, even though they may be difficult to read.

The May 15 issue of *Nature* has preliminary reports about scientific results from the flotilla of spacecraft that intercepted Halley's Comet last spring. Interesting pictures of the comet's nucleus by the Soviet *Vega* and the European *Giotto* spacecraft are published along with the experimenters' descriptions of what they might mean. Many other less-heralded scientific instruments were aboard each spacecraft, and those data and results are discussed as well. It is an historic issue of this popular British science magazine.

The blue-covered *Science* for July 4 does the same thing for the *Voyager* Uranus encounter. The *Voyager* scientists offer their first "official" publication of Uranus results, its tilted magnetic field, fascinating retinue of satellites, and unique system of rings. The reports are arranged by instrument, so there is a report about imaging, another about photometry, the infrared observations, ultraviolet data, radio, plasma waves and so on.

If the articles seem too technical, *Science* now regularly summarizes a few of its most interesting articles in each issue near the front of the magazine. And it carries readable "Briefings," like Richard Kerr's piece on the possible transience of planetary rings on page 27 of the same issue.

If you can find it, an excellent summary of last spring's Lunar and Planetary Conference may be found in the June issue of *Geotimes*, a publication of the American Geological Institute. Fifteen scientists summarize the Houston meeting's discussions of some central themes in planetary geoscience, including questions of subsurface volatiles beneath the surface of Mars, whether some asteroids are extinct comets, the origin of chondritic meteorites, the crustal evolution of Jupiter's moons, and experimental studies of cratering impacts.

An Historical Perspective

Science seems a thing of the present and the future, yet the past is the key to the future. Science is a process of thoughts and ideas interacting with experiments and data, and with other ideas, and slowly evolving into new perceptions about the nature of things. And successful space exploration involves the added element of learning from the history of technology.

Several recent articles discuss space science from an historical perspective. In the *Journal of Geological Education* for May, Ursula Marvin describes historical studies of meteorites, cratering and the Moon. She argues that the impact of "space geology" on traditional geology has been as profound as the revolution in geophysics that happened in the 1960s. In the May-June *Mercury*, Clyde Tombaugh reminisces about his discovery of Pluto. (For modern research about Pluto, look at the July issue of *Astronomy*.)

Lately the news magazines have been raising public concerns about a "hole in the ozone layer." It doesn't worry us too much, because it's way down in Antarctica. But if we think back to the 1970s controversies about the Supersonic Transport and about aerosol-spray-can pressurants, we should probably be much more worried. A thoughtful article in the June 9 *New Yorker* takes us back to the ozone battles through the eyes of atmospheric chemist Sherwood Rowland. Arcane argumentation during the past decade has gradually lulled us, and many scientists in that field, into a forgetful "what, me worry?" attitude. But suddenly scientists realize that the Antarctic "hole" means that they don't understand nearly as well as they thought they did how our planet works.

NASA Decisions, Past and Future

Another history of the 1970s is especially pertinent today as our nation struggles to renew the space program. John Logsdon, in the May 30 *Science*, reviews the history of how NASA and the United States chose to develop the space shuttle. The decision was made early in the tenure of James Fletcher as President Nixon's new NASA Administrator; inasmuch as Fletcher has just been reappointed by President Reagan to wrestle with our current dilemma, the article is worth close attention.

Logsdon argues that the 1972 policy decision was a clear failure — that it was made for the wrong reasons and in the wrong way. A presidential mandate was necessary, he thinks, and a long-term funding commitment was needed to support both shuttle development and NASA's science and applications programs. Nixon's decision was less than a mandate, and the Office of Management and Budget continued to chip away at NASA's funding during the early 1970s.

We may hope that James Fletcher soon convinces Reagan to act with bold vision to re-establish the American civil space program. An insightful summary of the choices has been written by Mitch Waldrop in *Science* for June 13.

Clark R. Chapman, an Arizona planetary scientist, recently co-organized an international meeting concerning the planet Mercury.

The Stars Our Destination?

The Feasibility of Interstellar Travel

by Robert L. Forward

It is difficult to go to the stars. They are far away, and the speed of light limits us to a slow crawl along the starlanes. Decades and centuries will pass before the stay-at-homes learn what the explorers have found. The energies required to launch a manned interstellar transport are enormous, for the mass to be accelerated is large and the cruise speed must be high. Yet even these energies are not out of the question once we move our technology out into nearby space where the constantly flowing sunlight is a never-ending source of energy — over a kilowatt per square meter, a gigawatt per square kilometer. There are many ideas on methods for achieving interstellar transport. In time, one or more of these dreams will be translated into a real starship.

Is It Possible?

Many people (some of them quite well known) have "proved" by "calculation" that interstellar flight is "impossible." Actually, in each case, all they have proved is that the initial assumptions they forced on the problem made it so difficult that they were unwilling to consider it further. Some examples of these "obvious" assumptions are: a self-contained rocket has to be used; to keep the humans inside the rocket comfortable, the rocket has to accelerate at a constant one-Earth gravity; all the energy needed to run the rocket has to be extracted out of Earth's resources; and, the mission has to be completed in 10 years.

Rapid interstellar travel with simple rocket technology is not feasible. If standard rockets are used to propel a space vehicle, the vehicle will be limited in its terminal velocity to a small fraction of light speed. If the spacecraft has a human crew, it will have to be designed as a "worldship" where the crew lives for many generations during the long journey between the stars. To get to the stars in less than a human lifetime, interstellar vehicles must use some form of "rocketless rocketry," where the vehicle does not carry its energy source, reaction mass or other parts of a conventional rocket. (In a chemical rocket the propellant *is* the reaction mass; it contains the energy to expel itself through the nozzle.)

Interstellar travel at a constant one-Earth-gravity acceleration is not feasible. After the first year of acceleration the vehicle is moving at 0.7 c (70 percent of the speed of light). From then on, the energy used for propulsion doesn't make the vehicle go significantly faster (to the people at home paying for the mission). Instead, all that energy just goes into making the vehicle heavier and harder to push. A properly optimized interstellar mission accelerates up to some cruise velocity that depends upon the mission and then coasts, cutting energy and fuel requirements by orders of magnitude.

Interstellar travel using only the resources of Earth is not feasible. The vehicles can be easily built with Earth resources (proposed interstellar unmanned probes might have masses from 20 grams to 100 tons, while manned exploration vehicles can go up to 100,000 tons). However, the reaction mass and especially the energy to drive the interstellar vehicles should be extracted from space.

Interstellar travel with roundtrip times of 10 years is not feasible. Even light requires 8.6 years to get to the nearest star system and back. By admitting that interstellar missions are going to require trip times of 30 to 50 years, the coast velocities needed to carry out a mission to the nearer stars drop from more than 0.9 c to less than half the speed of light. This eliminates many problems, such as the erosional effects of the interstellar medium.

If one uses "obvious" but improper assumptions like those mentioned above, one can show that interstellar travel is not feasible. Yet, as we shall see, interstellar travel *is* feasible if instead the *proper* assumptions are made and the proper techniques are used.

The first travelers to the stars will be our robotic probes. They will be small and won't require amenities such as the food, air and water that humans find necessary. The power levels to send the first flyby probes are within the present reach of the human species. If we started today, we could have the first flyby interstellar probe on its way before the present millennium is out.

Interstellar Distances

It is not easy to comprehend the distances involved in interstellar travel. Of the billions of people living today on this globe, many have never traveled more than 40 kilometers from their place of birth. Of these billions, a dozen have traveled to the Moon, which at almost 400,000 kilometers distance is 10,000 times 40 kilometers away. Soon, one of our interplanetary probes will be passing Neptune, 10,000 times farther out at 4,000,000,000 kilometers. However, the nearest star, at 4.3 light years, is 10,000 times farther than that.

To carry out even a one-way probe mission to the nearest star, in the lifetime of the humans that launched it, will require a minimum velocity of 0.1 c (10 percent of the speed of light). At that speed it will take the probe 43 years to get there and 4.3 years for the information to get back to us. The nearest star is Proxima Centauri, part of a three-star system called Alpha Centauri. One of the stars is similar to our Sun.

Farther away are other single stars similar to our Sun that are our best candidates for finding an Earth-like planet. These are Epsilon Eridani at 10.8 light years and Tau Ceti at 11.8 light years. To reach these stars in a reasonable time will require probe velocities of 0.3 c. At this speed it will take nearly 40 years to get there, plus another 11 to 12 years for the information to return to Earth.

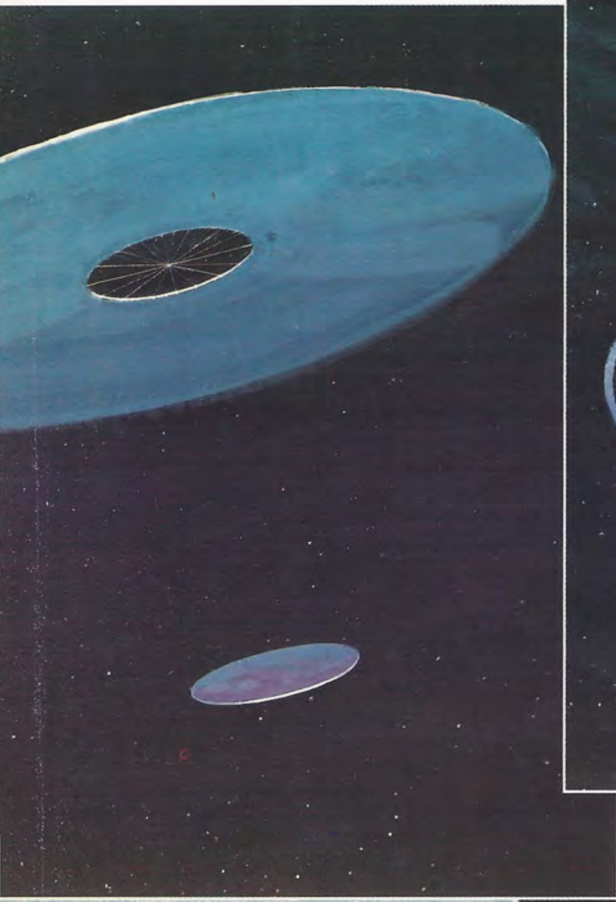
Yet, although we need to exceed 0.1 c to get to any star in a reasonable time, if we can attain a cruise velocity of 0.3 c, then there are 17 star systems with 25 visible stars and probably hundreds of planets within 12 light years. This many stars and planets within reach at 0.3 c should keep us busy exploring while our engineers are working on faster starship designs.

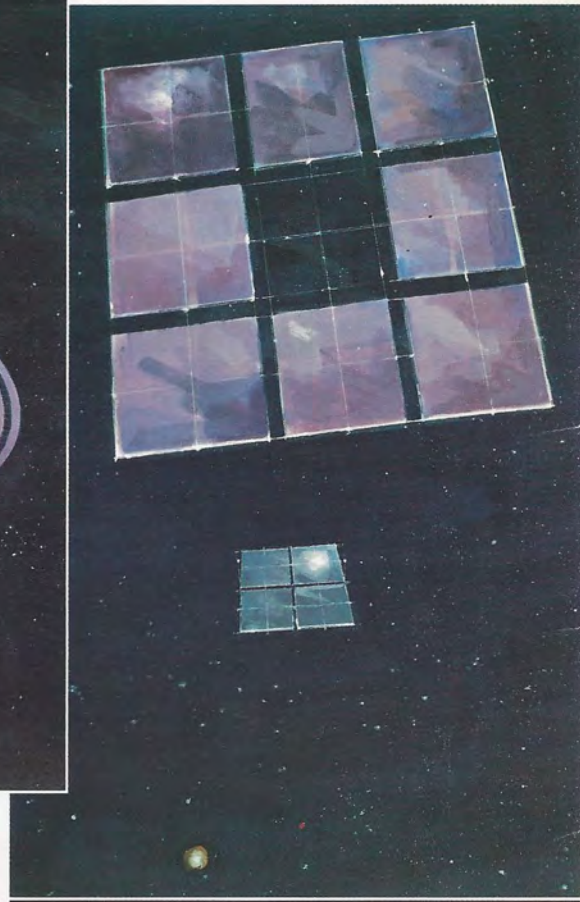
Rocketless Rocketry

We need not use the rocket principle to build a starship. If we examine the components of a generic rocket, we find that it consists of payload, structure, reaction mass, energy source, an engine to put the energy into the reaction mass, and a thruster to expel the reaction mass to provide thrust. In most rockets the reaction mass and energy source are combined together into the chemical fuel. The fuel is burned in the engine and then expelled through the thruster. Because a standard rocket has to carry its fuel along with it, its performance is significantly limited.

There is a whole class of spacecraft that do not have to carry along any energy source or reaction mass or even an engine, and consist only of payload, structure and thruster. These spacecraft work by beamed power propulsion. In a beamed power propulsion system, the heavy parts of a rocket (the reaction mass, the energy source and the engine) are all kept in the solar system.

(continued on page 13)





CLOCKWISE FROM TOP:

Starwisp: A microwave beam pushes a small mesh probe on an interstellar trajectory. A solar-powered satellite, normally used to beam microwave power to Earth, could be used for one week to push a 20-gram, 1-kilometer-diameter, wire-mesh structure to up to 20 percent the speed of light.

Rectangular Laser-Pushed Lightsail: Many different shapes are possible for craft traveling under light power.

Interstellar Probe: Green laser light from a solar-pumped laser near the Sun could push a small, 1,000-kilogram, 1-kilometer-diameter interstellar probe up to 0.1-0.2 percent of light speed.

Interstellar Rendezvous: Laser light from our solar system bounces off a 1,000-kilometer-diameter ring sail onto a 320-kilometer-diameter rendezvous stage, decelerating it to a stop in its target star system.

Return from the Stars: Laser light from our solar system bounces off the 320-kilometer-diameter ring sail back onto the 100-kilometer-diameter return stage, which carries the crew and samples back to their home. The crew quarters would be invisible on this scale.

Paintings by Seichi Kiyohara

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Here, around the Sun, there are unlimited amounts of reaction mass readily available, and the energy source (usually the abundant sunlight) and engine can be maintained and even upgraded as the mission proceeds.

Starwisp: A Maser-Pushed Probe

Starwisp is a lightweight, high-speed interstellar flyby probe pushed by beamed microwaves. The basic structure is a wire mesh sail with microcircuits at each intersection. The mesh sail is pushed at high acceleration using microwave power formed into a beam by a large segmented transmitter lens made of alternating sparse metal mesh rings and blank rings. The high acceleration allows Starwisp to reach a coast velocity near that of light while still close to the transmitting lens.

Upon arrival at the target star, the transmitter floods the star system with microwave energy. Using the wires as microwave antennas, the microcircuits on Starwisp collect energy to power their optical detectors and logic circuits to form images of the planets in the system. The direction of the incoming microwave beam is sensed at each point of the mesh and that information is used to electronically transform the mesh into a microwave antenna that beams a signal back to Earth.

A minimal Starwisp would be a one-kilometer mesh sail weighing 16 grams and carrying 4 grams of microcircuits. Starwisp would be accelerated at 115 gravities by a 10 gigawatt microwave beam, reaching one-fifth the speed of light in a few days. Upon arrival at Alpha Centauri 21 years later, Starwisp would collect enough microwave power to return a high resolution color television picture during its fly-through of the system.

Because of its very small mass, the beamed power level needed to drive a minimal Starwisp is about that planned for the microwave power output of a solar power satellite. Thus, if power satellites are constructed in the next few decades, they could be used during their checkout phase to launch one or more Starwisp probes to the nearer stars.

Once the Starwisp probes have found interesting planets, then we can use another form of beamed power propulsion to visit them. Although microwave beams can only be used to "push" a spacecraft away from the solar system, if we go to laser wavelengths, then it is possible to design a beamed power propulsion system that can use laser power sent from the solar system to make a return journey.

Laser-Pushed Lightsails

One of the best methods for traveling to the stars would use large sails of light-reflecting material pushed by the photon pressure from a large laser array in orbit around the Sun. With this technique we can build a manned spacecraft that not only can travel at reasonable speeds to the nearest stars, but can also stop, then return its crew back to Earth again within their lifetimes. It will be some time before our engineering capabilities in space will be up to building the laser system needed, but no new physics is involved, just a large-scale engineering extrapolation of known technologies.

The lasers would orbit Mercury to keep them from being blown away by the reaction from their light beams. They would use the abundant sunlight at Mercury's orbit to produce coherent laser light, which would be collected into a single coherent beam and sent out to a segmented transmitter lens floating between Saturn and Uranus. The transmitter lens consists of rings of one-micron-thick plastic film alternating with empty rings. Because it is crude in construction it only works well at one wavelength of light. We chose the laser wavelength to match the design wavelength of the lens. The lens would be 1,000 kilometers in diameter with a mass of 560,000 tons, about the mass of a solar power satellite. A lens this size can send a beam of laser light over 40 lightyears before the beam starts to spread.

The lightsail carrying the payload would be 1,000 kilometers in diameter and made of thin aluminum film stretched over a supporting structure. The total mass would be 80,000 tons, including 3,000 tons for the crew, their habitat, their supplies and their exploration vehicles. The lightsail would be accelerated at 0.3 gravities by 43,000 terawatts of laser power. (For comparison, Earth now produces one terawatt of electrical power. We would certainly want to power the lasers by collecting sunlight from space with large reflectors rather than attempting to use Earth-based power sources.) At this acceleration, the lightsail will reach a velocity of half the speed of light in 1.6 years. The expedition will reach Epsilon Eridani in 20 years Earth time and 17 years crew time, and it will be time to stop.

At 0.4 light years from the target star, the 320-kilometer rendezvous portion of the sail is detached from the center of the lightsail and turned to face the large ring sail that remains. The laser light from the solar system reflects from the ring sail, which acts as a retro-directive mirror. The reflected light decelerates the smaller rendezvous sail and brings it to a halt in the Epsilon Eridani system.

Returning Home

After the crew explores the system for a few years (using their lightsail as a solar sail), it will be time to bring them back. To do this, a 100-kilometer-diameter return sail is separated from the center of the 320-kilometer rendezvous sail. The laser light from our solar system hits the ring-shaped remainder of the rendezvous sail and is reflected back on the return sail, sending it on its way back to the solar system. As the return sail approaches the solar system 20 Earth-years later, it is brought to a halt by a final burst of laser power. The members of the crew have been away 51 years (including 5 years of exploring), have aged 46 years, and are ready to retire and write their memoirs.

It is important to recognize that although interstellar unmanned probes and manned starships are possible, they will be difficult to build and expensive. The masses needed to make any kind of interstellar transportation system and the power levels to operate it will require that we first have a large industrial base in space. A space station with 20-100 people in space at one time is not enough. We will need many space stations, bases on the Moon, prospectors in the asteroid belt, and solar power stations for processing materials and powering the factories. This is 20 to 50 years away.

A simple example is the amount of power needed to carry out an interstellar mission. No matter what propulsion method you can dream of, to accelerate a one-ton interstellar probe up to one-third the speed of light, even over a three-year period, requires a power input of 50 gigawatts. Even at 50 percent efficiency this requires a power input of 0.1 terawatt. (One gigawatt equals one billion watts; one terawatt equals one trillion watts.) This is one-tenth Earth's present output of electrical power. For a crewed vehicle weighing 10,000 tons, the power required is 1,000 terawatts. To get this power we must be out in space where sunlight supplies over one kilowatt per square meter and have the manufacturing capability to build solar collectors 1,000 kilometers in diameter.

The masses required for these large structures are not trivial either. These solar collectors, thin aluminum and microwave lenses made of fine wire, will weigh between 50,000 and 100,000 tons, while laser lenses with one-micrometer (1/1,000th of a meter) thick plastic will reach 600,000 tons. For the microwave lens, this mass can be obtained from a nickel-iron asteroid 25 meters in diameter, while the aluminum can be obtained from a stony asteroid 100 meters across. The plastic will have to be made from carbonaceous chondrites perhaps one kilometer in diameter. These are modest-sized asteroids, but all that mass has to be processed in a reasonable time and that will take a very big factory.

New Industrial Revolution

But in 20-50 years it is likely that there will be a new industrial revolution where robots take over all labor, leaving management to humans. Suddenly, labor costs may disappear; only capital, energy and material costs would be left. Especially for such simple structures as solar collectors and segmented ring lenses, robots would be more than adequate for construction.

Once we have the space industrial base, once we have found the right asteroids, then we can invest a little capital in a small crew of smelter and spinner robots and a solar collector to provide energy. We go away and come back in a few years to find the asteroid gone and a wire-mesh microwave ring lens in its place. During the fabrication phase the waste products from the smelting operation have been heated and expelled to provide thrust to move the whole system to the position and velocity desired (typically far from the Sun and not orbiting a planet).

What will this cost? A lot — but not as much as you might think if you attempted to do it with material hauled up on the expensive space shuttle and assembled by expensive human beings.

It is difficult to go to the stars, but it is not impossible. Many different technologies, all under intensive development for other purposes, if suitably modified and redirected, can give the human species a flight system that will reach the nearest stars. All it really takes is the desire and the commitment to a few decades of hard space engineering work. Our first interstellar probe could be heading to the stars within our lifetimes.

Dr. Robert L. Forward is an advanced propulsion scientist at Hughes Research Laboratories in Malibu, California. He also writes science fiction.

SOCIETY *Notes*

VOLUNTEER NETWORK

Many members have asked how to become more involved in Planetary Society activities to help promote our goals. We have developed an exciting new plan to make active involvement possible.

We are organizing a worldwide "Planetary Society Volunteer Network." If you become a volunteer, your name and geographic location will go in a computer file to help us keep you informed about events and activities. Here are some areas where you can make a valuable contribution to the Society:

Society Displays – Set up Planetary Society displays in local libraries, museums, shopping centers and other public places. The Society will send you display materials with instructions on setting them up.

Recruiting New Members – Encourage people to join the Society. As our membership grows, the Society will have a greater ability to accomplish its goals. We are already the largest space-interest group in the world. But the more members we have, the more effective we are.

Lecture Programs – Set up lecture programs. Our goal is to sponsor lectures throughout the United States focusing on future space exploration. A videotape produced by the National Commission on Space is available for showing, and the Society can provide a scientist to lead discussions. Other topics might include the Search for Extraterrestrial Intelligence (SETI), Mars exploration, the *Voyager* project and the recent expeditions to Halley's Comet. Public forums throughout the country will give those vitally interested in the space program – and its future – a place to express their views.

Volunteer Coordinators – We need leaders who can coordinate the activities of local members, increasing the effectiveness of our volunteer corps.

To become a Planetary Society volunteer or volunteer coordinator, write or call Lyn McAfee at the Society office, 65 N. Catalina Avenue, Pasadena, CA 91106, (818) 793-5100. We will send you an application form so we can get an idea of your interests, experience and skills. Return the form and become part of the PSVN — the Planetary Society Volunteer Network.

NEW MILLENNIUM COMMITTEE STILL GROWING

David Brown, chairman of the Society's New Millennium Committee, announced that the committee has two new members. They are George Awad of New York City and Andrew Peller of Hamilton, Ontario. The committee has made major contributions to Society projects that will extend into the 21st century, the beginning of a new millennium.

To find out more about the New Millennium Committee, write to David Brown in care of our Pasadena office.

HELP WANTED BOOKING LECTURES

A person with experience in booking lectures is needed to fill a volunteer position at The Planetary Society. Responsibilities will include booking a Society lecture series. The public lecture program is an important way to spread the word about planetary exploration. The scientists are ready to lecture — we need places to send them. If you have experience and are interested in helping, write Louis Friedman at our Pasadena office.

HALLEY'S COMET FILMED

A unique project — photographing Halley's Comet from Earth with a fast CCD (charge-coupled device) camera — was made possible in part by funding and other assistance from The Planetary Society. From the Siding Spring Observatory in Australia, Drs. Terrence Rettig and Alan Baumbaugh of the Physics Department at the University of Notre Dame photographed the comet for 25 nights as it progressed through the sky. They recorded 90 hours of enhanced and digitized images showing changes in the comet as they occurred. These observations will be added to the International Halley Watch data bank, and will contribute to the understanding of comets.

MEMBERS THRONG TO JUNE EVENTS

At the Heard Museum in Phoenix, Society Executive Director Louis Friedman and National Commission on Space Vice-Chairman Laurel Wilkening talked about "The Future of Space Exploration," comparing planetary exploration by the United States and by the Soviet Union. Phoenix members responded enthusiastically and asked many thought-provoking questions.

At Pasadena's Jet Propulsion Laboratory, our Southern California members watched a videotape describing the National Commission on Space report. Louis Friedman led a discussion about the future of space exploration. It was a standing-room-only crowd, and many members stayed well beyond the program's end to discuss this important topic.

NASA'S MARS CONFERENCE

This July in Washington, DC, NASA held a conference on future exploration of Mars. Society President Carl Sagan chaired and Society Vice President Bruce Murray participated in a panel discussion, "Mars: Another Giant Leap for Mankind."

That same day Dr. Sagan also testified about the recommendations of the National Commission on Space at hearings in the House of Representatives and with Dr. Thomas Paine (see pages 3-6) gave a well-attended press conference in the House on the Commission report and on Dr. Paine's joining the Society's Board of Directors.

At the conference, the Society showed a specially commissioned series of paintings depicting an international mission to Mars. Mars Institute engineer Tom Meyer demonstrated the "Mars Network" computer system at our display. "An Explorer's Guide to Mars," our poster-sized map of Mars, was unveiled, and "Exploring Other Worlds," a videotape about the Society by Jon Lomberg, was shown on the lawn of the National Academy of Sciences. A group of graduate students from the University of Arizona demonstrated their Mars Ball, a vehicle designed to roam the martian surface. The Society helped fund the demonstration.

IS ANYBODY OUT THERE?

Nova, the PBS documentary series, will take a look at the Search for Extraterrestrial Intelligence in "Is Anybody Out There?", a show airing Tuesday, November 18 at 8:00 pm (check your local listings). Project META (Megachannel Extraterrestrial Assay), the radio search conducted by Harvard Professor Paul Horowitz and funded by The Planetary Society, will be prominently featured.

Lily Tomlin, who recently won a Tony award for her Broadway play "The Search for Signs of Intelligent Life in the Universe," narrates the show and performs as Ernestine, the telephone operator. Geoffrey Haines-Stiles produced and co-wrote the show with astronomer Donald Goldsmith. Artist Jon Lomberg, who designed the Planetary Society logo, directed the visual effects.

Tune in November 18 to *Nova* to see how your contributions to the Society have made possible the most advanced SETI project now underway. □

(***A Time To Act***/*cont. from page 7*)

known. It would permit the development of a logical launch vehicle plan, appropriately mixing piloted and automatic vehicles. And, most important, it would make the space program serve America's broader national interests and security. If the United States and the Soviet Union can join together to lead humanity to another world, new opportunities for harmony and peace on Earth will have been created.

It is the responsibility of the President, Congress and the Administrator of NASA to set new long-range goals for the US civilian space program (see the July/August 1986 *Planetary Report*). The officers of The Planetary Society have been leading the call to set new goals and revitalize the space program. They have testified to Congress, conferred with leaders of the House and Senate, met with top officials in the White House, NASA, the Department of State, the National Security Council, and the Office of Management and Budget; they have briefed congressional staff, written articles, given interviews, and worked with other constituencies and study groups, such as the United Nations Association-USA.

Planetary Society members can also act to demonstrate popular interest and to protest the aimlessness of the US civilian space program. The President must set the goal in space, just as John F. Kennedy did 25 years ago when he set the United States on a course to the Moon. Opening Mars to human exploration in cooperation with the Soviet Union, the European Space Agency and other nations, on behalf of our entire planet, can provide the missing long-term goal of NASA.

The most important person to write is:
President Ronald Reagan
The White House
Washington, DC 20500

Send copies or additional letters to:

Dr. James Fletcher
Administrator, NASA
NASA Headquarters
Washington, DC 20546

White House Science Advisor
Old Executive Office Building
Washington, DC 20500

Sen. Slade Gorton
The Committee on Commerce, Science and Transportation
United States Senate, SD 508
Washington, DC 20510

Rep. Bill Nelson
The Committee on Science and Technology
United States House of Representatives
2321 Rayburn HOB
Washington, DC 20515

And please send copies of your letters to The Planetary Society.

Louis Friedman is the Executive Director of The Planetary Society.

MARS BASE 2035 AD — Explorers at an advanced Mars outpost investigate the universe and mine the planet in this painting by Robert T. McCall. In the foreground, an astronomical observatory sits on top of a specially constructed Mars lander. Three other landers are loaded with cargo for a mining operation, underway at the right.

Artist Robert T. McCall has been documenting the US space program for 26 years, specializing in humans in space. "The Space Mural, A Cosmic View," his six-story-high mural celebrating the Apollo adventure, is displayed in the Smithsonian Institution in Washington, DC.

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