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COVER: Suspended in space above Mexico on April 7, 1983, astronauts Donald H. Peterson and F. Story Musgrave (with dark bands on his suit) work outside the cargo bay of* Challenger. *NASA's fleet of shuttles may carry the components of a space station into low-Earth orbit, to be assembled into a permanent facility. ***PHOTO: JOHNSON SPACE CENTER/NASA***

Letters to the Editor

We recently appealed to our members for funds to begin a Planetary Society education program. We also printed a request for help developing the program in the January/February 1984 Planetary Report. Not only did we receive generous donations, many members offered ideas and volunteered their time. In this Letters to the Editor column, we would like to share some of the responses with you.

I recently read, with great interest, your ideas regarding The Planetary Society and education of our country's youth. I applaud your willingness to take the initiative and help reverse the anti-science sentiment and strongly negative feelings that have pervaded our educational system and the nation as a whole for the past decade or so.

The study of space, astronomy and science is an exciting adventure. It can be a challenge which, through our encouragement, our youngsters *can* and *will* become eager to confront and surpass. It can expand their knowledge and horizons beyond what is presently expected. These future citizens of the United States (or should I say "Citizens of Planet Earth") should develop an increasing understanding of the world in which they will inevitably exert increasing control. If space, the planets, and, ultimately, the stars are to be our new, expanded backyard, then it is incumbent upon us to give our children the greatest possible understanding of the *world* in which they live.

RICHARD A. WOLFERT, *North Richmond Hill, New York*

I think the problem has three major components—two of which The Planetary Society could directly address. First, many teachers who are teaching planetary science have no formal education in this area and need clear *up-to-date* information both on the factual level and on research issues involved. Second, the field of planetology is changing rapidly and these changes must be addressed. Third, there has to be a commitment at the community and school administrative level of financial support for the classroom teacher with the necessary educational and audio-visual materials.

The excitement of modern planetary science is very real to many students, but the classes can sometimes lose enthusiasm in a myriad of facts and figures. Any program dealing with this area—certainly at the junior high level—*must* include its relevance not only to the bank of scientific knowledge, but to the individual as well, on both a scientific and philosophic level, i.e., the challenge of today's research to human imagination.

PAUL TERRY, *The Hague, The Netherlands*

We agree with your recent letter in which you point out the lack of up-to-date information about planetary sciences in school curricula. In fact, in many schools even out-of-date information is lacking! A major problem lies with teachers. They feel uncomfortable with much of planetary sciences because the material is not part of the classical curriculum that they were taught. Secondly, the information is not in easily digestible form.

We think that a main target for education through The Planetary Society should be teachers. Educating a few good teachers would lead to dissemination of information to a large number of students. A quality program need not be developed from scratch; existing ones can be used as the foundation for Planetary Society efforts.

RAYMOND E. ARVIDSON, RICHARD HEUERMANN, *St. Louis, Missouri*

[Dr. Arvidson is Associate Professor, Department of Earth and Planetary Sciences, Washington University, and Mr. Heuermann is Administrative Officer at Washington University. Both have been affiliated with Project PULSAR, a curriculum enrichment package for the classroom, produced by the St. Louis Science Center.]

CONSIDERING A SPACE STATION

In his 1984 State of the Union address, President Reagan proposed to Congress that NASA build a permanently manned space station within the next decade. Here we present views of the space station proposal. In an article that first appeared in the Washington Post, *science writer Mark Washburn analyzes the debate over President Reagan's proposal and summarizes the issues we should consider. Dr. Hans Mark, Deputy Administrator of NASA, expresses the enthusiasm of the space agency for this project that would rival* Apollo *in scope. Dr. Thomas Donahue, Chairman of the Space Science Board of the National Academy of Sciences, details the concerns of scientists who fear that this engineering project may swallow support for science.*

What position should The Planetary Society take on the space station proposal? We welcome an international space initiative. But a technological project with no defined exploratory or utilitarian value is worrisome in this era of tight budgets. Members are invited to consider the viewpoints, and then use the questionnaire in this issue to contribute to the Society's position on a space station.

What's a Space Station Good For?
by Mark Washburn

A Strauss Waltz plays as the gleaming space station rotates like a giant, high-tech wagon wheel in the inky void. A shuttle glides toward the busy docking bay, where another shuttle is being readied for the commute back to Earth. Inside the station, in the zero-gravity hub, scientists conduct experiments while engineers monitor space "factories" where computer chips and pharmaceuticals are being manufactured.

This is the Hollywood version of a space station, and the picture that many Americans probably have of it. But it is a far cry from the manned facility that Ronald Reagan has approved. The real thing will be a small, isolated outpost in a hostile environment, difficult and expensive to reach, tedious to live in and limited in its capabilities for conducting either scientific research or commercial operations. It will take nearly a decade to build and undoubtedly will cost far more than the current $8 billion price tag.

Reagan apparently was won over to this project by a vision of enhanced American prestige in space—a sort of Stanley Kubrick version of "America is back"—and by the prospect of a new frontier of commercial enterprise. In his State of the Union address, the President emphasized the role of the private sector in space, and there are signs that industry and private entrepreneurs are picking up on his lead.

But large as the potential scientific and industrial benefits may be from this project, the country would do well to consider carefully what it is getting for its money—and what other options may be available in space—before plunging ahead.

The manned space station will pre-empt vast amounts of money that could go to other endeavors, ranging from scientific exploration of the planets, to robot probes of the asteroids that could have long-term commercial benefits. Unresolved questions about our space priorities remain, and conflicts continue to fester between groups with different interests: scientists, supporters of commercial exploration and engineers whose priority is manned space exploration.

The space station, long a goal of the National Aeronautics and Space Administration, had (and still has) a powerful group of critics. They include presidential science adviser George A. Keyworth II, who has expressed concern about the emphasis on manned activities, the Pentagon, which sees no military mission for the facility, and the Office of Management and Budget, which is worried about the cost. This type of space station was also opposed by large segments of the scientific community, which would prefer to see the money spent on scientific experiments and unmanned projects.

To be sure, the station's commercial role may represent the shape of things to come. There are signs that the possibility of manufacturing in space is, at last, beginning to move out of the realm of fantasy and onto corporate drawing boards. Drug production, for example, is a potentially fruitful field. McDonnell Douglas and Johnson & Johnson already have developed procedures for manufacturing pharmaceuticals in space by a process called electrophoresis, which uses the gravity-free environment to purify biological materials such as enzymes and hormones. Johnson & Johnson researchers are looking at 30 to 40 possible products, including insulin and interferon.

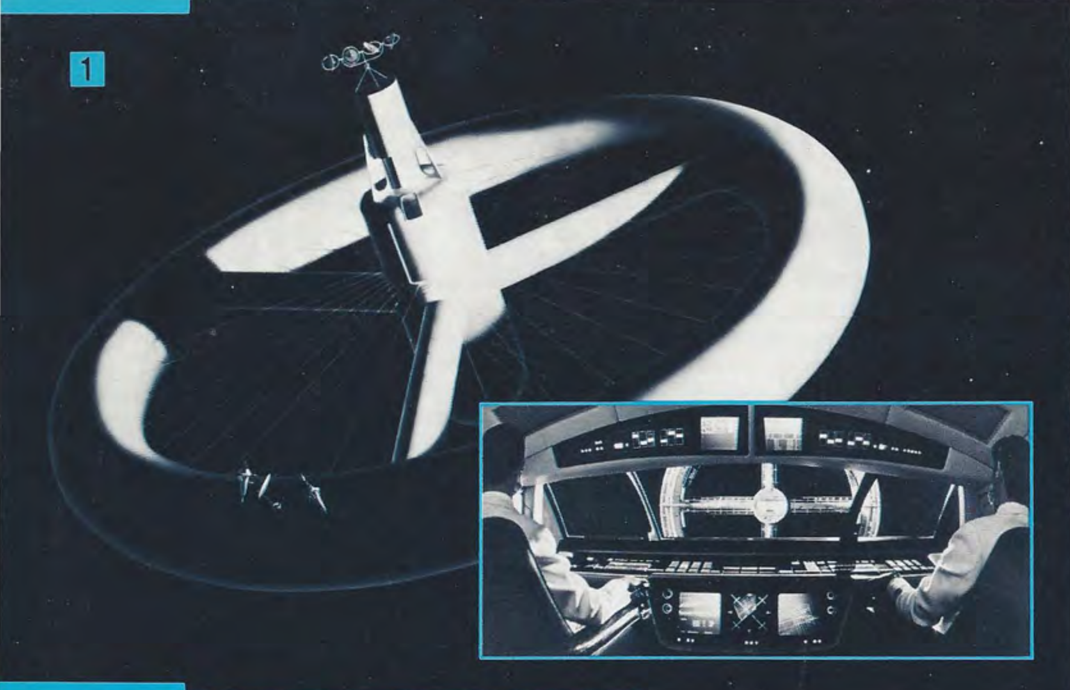
The computer industry is also looking skyward. IBM recently abandoned a 20-year effort to develop low-temperature computer technology in favor of a new generation of gallium arsenide "superchips." Gallium arsenide crystals have been found to grow extremely well in zero gravity.

Space is also beginning to attract the attention of venture capitalists and private entrepreneurs. Last month, a former NASA official announced he had formed a private company to build a robot space station that could be placed in orbit by the shuttle before the completion of the government's more advanced station. It would be a small platform that could be leased for manufacturing and could be serviced by shuttle astronauts.

Fairchild Corp. is planning a more ambitious, cube-shaped orbital platform for manufacturing that could be launched by the shuttle as early as 1987. McDonnell Douglas' pharmaceutical factory may be the first payload for the facility, which has been called Leasecraft and would carry automated factories or experiments into orbits as high as 1,000 miles and return them to low orbit for periodic servicing by the shuttle. Customers would rent space aboard the Leasecraft for about $3 to $5 million per month.

Despite this upbeat news, though, there are big economic, technological and political obstacles to using space as a new industrial frontier, as envisioned by space station proponents. In the '60s and '70s, it was possible to parlay a good idea, an empty garage and $100,000 into an electronics empire. But a space entrepreneur's good idea would require more like $100 million to turn it into reality.

"We don't yet have a firm customer for Leasecraft," says John Naugle, a former NASA official who is now senior director of the Leasecraft program. Naugle hopes for a definite commitment from McDonnell Douglas by July of this year. But McDonnell Douglas, in terms of research and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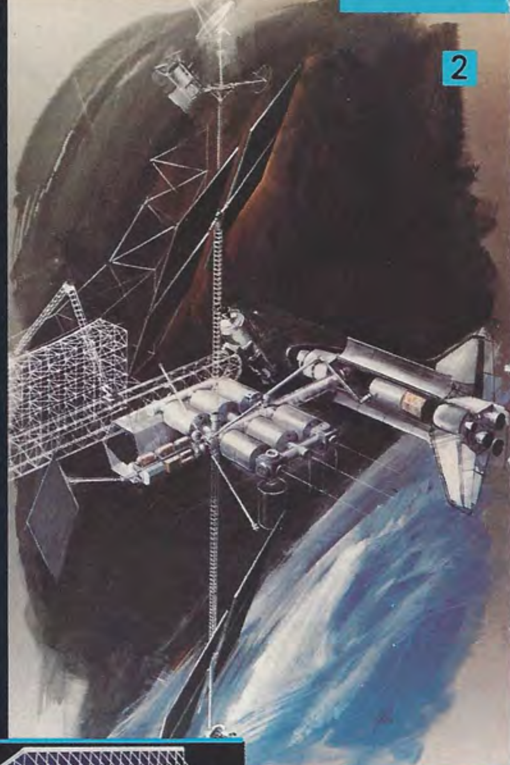
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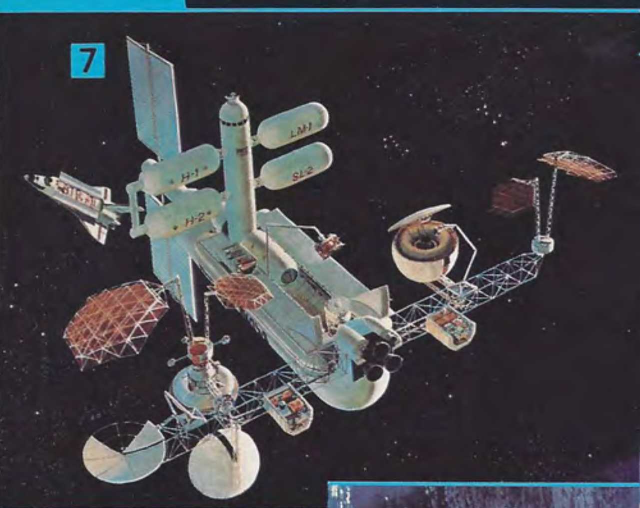
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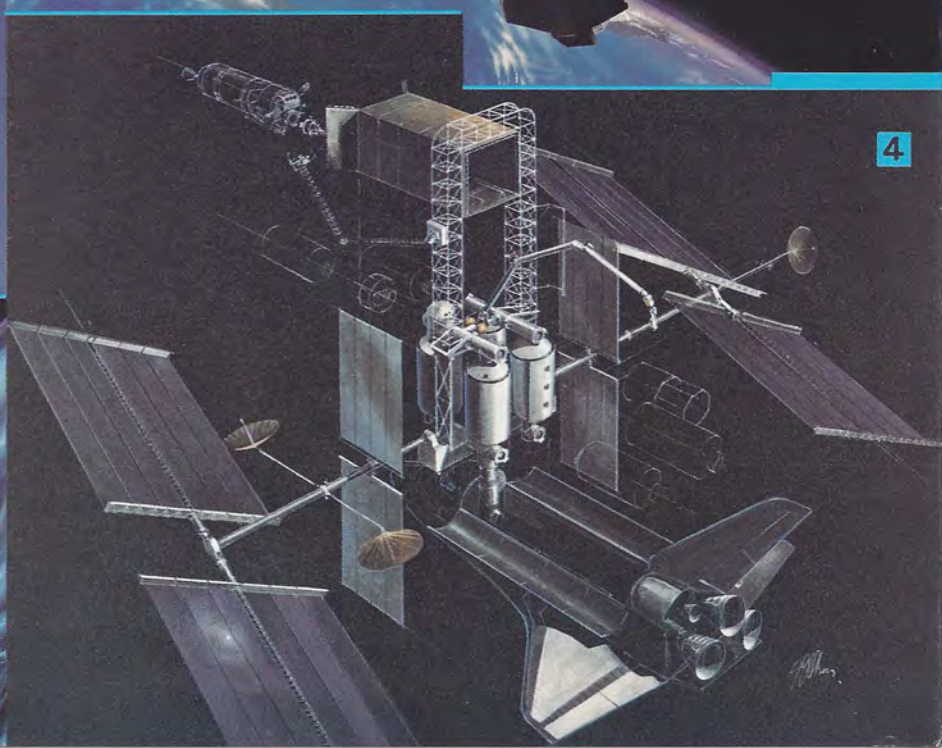
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development, is years ahead of any other potential customer. "There is a lot of interest," says Fairchild's William Fullwider, "but there is reluctance to take the first step. Our feeling is that once it does happen, things will begin falling in line."

Outside the aerospace industry, however, there seems to be little appreciation of the commercial possibilities offered by a gravity-free, vacuum environment. "The educational process is underway," says Naugle.

It will be an expensive education, with little hope of profits in the near future. In the case of microelectronics, the price of producing space-grown gallium arsenide crystals is daunting: about $30,000 an ounce. And the government space station will not be ready for 10 years—a millennium in the fast-paced computer industry.

What comes down from space must first go up. But no private launching capacity yet exists, so any industrial exploitation of space depends at this point on a government subsidy, in the form of a ride on the shuttle. Does this administration, which is so in favor of free enterprise, really want to become involved in this kind of government "targeting" of growth industries in space?

As the twin failure of booster rockets for the Westar and Palapa satellites on the last shuttle trip showed, the financial risks are huge. The two satellites were insured for $75 million each. As one businessman said recently, industry is reluctant to "put a billion dollars into orbit."

Given these uncertainties, the current excitement in Washington over the commercial possibilities of a manned space station has scientists worried. They fear that the project will swallow up funds that could better be spent on other endeavors with bigger long-term payoffs. They fear that the engineers and enthusiasts of manned activity in space will get the lion's share of the funds—as happened during the *Apollo* program, and later during the production of the shuttle.

NASA's planetary exploration program was especially hard hit by the shuttle. The spectacular successes of the *Viking* mission to Mars and the *Voyager* mission to the outer planets have not been followed up by new missions. During the shuttle-building era, only one new planetary mission was funded, and that—the 1986 *Galileo* mission to Jupiter—has faced repeated delays due in part to problems with the shuttle, which is to be the *Galileo* launch vehicle.

Hoping to avoid another hiatus, NASA established the Solar System Exploration Committee (SSEC) in November 1980 with the intention of designing a logical, practical, and inexpensive planetary strategy for the '80s and beyond. The first report of the group, which was dominated by scientists, recommended a core program consisting of 14 new missions, two of which have received start-up funds. The Venus Radar Mapper, with a planned 1988 launch date, should give scientists a detailed look at the surface of that cloud-shrouded sister planet. The 1990 Mars Geoscience Climatology Orbiter will be the first American mission to the Red Planet since the two *Viking* spacecraft landed there in 1976. In addition, the SSEC hopes to win approval for a comet rendezvous and/or asteroid flyby mission, and a Saturn orbiter with a probe of Saturn's moon, Titan, to take place in the early or mid-1990s.

Scientists' optimism about the SSEC program has been tempered by the 1985 Reagan budget proposal, however. Although the administration signed on for the Venus and Mars missions, funds have not been allocated for the development of the Planetary Observer spacecraft, which is regarded as a keystone to the SSEC plan. Also, funds for the analysis of data already collected by *Viking* and *Voyager* have been cut back. Some scientists regard the budget proposal as an implied rejection of the basic SSEC program. The omissions in the budget proposal, they fear, may be harbingers of the same sort of slow death-by-attrition that the SSEC was designed to prevent.

Another worry is that even after experiments are built and launched, the funding needs of the space station may cut into operating budgets, as has happened in the past.

If the SSEC program survives, planetary scientists should enjoy a modest renaissance during the coming decade. The *Galileo* spacecraft, to be launched in 1986, will arrive at Jupiter in 1988 and drop a probe into the seething atmosphere of that giant planet. During the following three years, the *Galileo* Orbiter will return data about Jupiter's four major moons, Callisto, Ganymede, Europa, and Io. The pictures should be even more spectacular than those from *Voyager*; surface details as small as 20 meters across will be seen on Ganymede and Io.

Galileo is supposed to be followed by the Venus and Mars missions, and possibly two others. One is a mission to the asteroid belt that would give us our first detailed look at a potentially important class of astronomical objects. Metals and organic materials mined from the asteroids may become a primary resource for both Earth and space in the 21st Century. (In the long run, it will be cheaper to mine the moon and asteroids than to ferry raw material to bases and stations in space from Earth.)

The other mission, to Saturn, would send a probe into the opaque atmosphere of the giant moon Titan, where a planet-wide ocean of complex organic molecules may mimic conditions on Earth before life began.

Meanwhile, *Voyager 2* is still alive and reasonably well. Launched in 1977, it is headed for a January, 1986 encounter with the planet Uranus and, if the spacecraft survives, an August, 1989 flyby of Neptune.

Barring funding cuts incurred by the space station, non-planetary scientists should also have a productive decade as a result of the scheduled launching aboard the shuttle of the Hubble space telescope in 1986. It will see seven times deeper into the universe than the biggest and best ground-based observatories.

If these U.S. scientific projects sound lavish, it is worth noting that other nations are also busy pursuing scientific goals. The Soviet planetary exploration program continues to focus on Venus, where *Venera* probes have already made successful landings. A joint Soviet-French mission to Halley's Comet is scheduled for 1986. Halley will also be the target of a Japanese scientific mission, launched by a Japanese rocket, and the European Space Agency's first independent deep space effort, the *Giotto* mission.

Despite the valuable knowledge gained from scientific endeavors, the Reagan administration seems to want a more tangible return from its space investment.

At this point, the shuttle is central to the entire U.S. space effort. It is needed to launch scientific experiments, commercial tests and, ultimately, to carry aloft the components of the manned station.

The shuttle has limitations. Its range is extremely limited. Due to its fuel capacity and other design factors, it cannot fly much higher than about 300 miles above a sphere 8,000 miles in diameter: if the Earth were a peach, the shuttle would barely be above the fuzz. But the real action in space, experts agree, will take place in geosynchronous orbit, 22,300 miles above the surface of the planet. The low shuttle orbits are worthless for communications satellites and present a variety of difficulties for industrial and scientific operations (for example, corrosion from oxygen atoms from the upper atmosphere). While the shuttle is adequate for research and development, it cannot stay aloft long enough for full-scale production operations.

The administration's proposed answer to the latter problem is the space station. The station would be composed of four to six modules and would be home for six to eight astronauts, who would spend up to three months aboard before being rotated home. In an environment similar to Antarctic research stations or atomic submarines (think of "Run Silent, Run Deep," not "2001"), the astronauts would

Many people envision a space station as a sleek, spoked structure whirling in space to simulate gravity, and regularly served by shuttles from Earth. This was the type of station imagined by Disney animators (1) and the makers of "2001: A Space Odyssey" (inset). The actual space station will more likely be an assemblage of modules that can be carried into low-Earth orbit by the space shuttle. NASA and several aerospace companies have been working on station design. The artists' conceptions presented here are from: (2) Boeing Aerospace Co., (3) NASA, (4) Boeing Aerospace Co., (5) NASA, (6) TRW Inc., (7) General Dynamics Corp.

conduct experiments, carry out research programs and supervise the operation of commercial ventures.

According to Bruce Abell of the White House science office, "Almost anything you're talking about doing in space will require a space station. It's appropriate to view a space station as a kind of doorway."

However, some see it differently. "The contention that this is a way station to the planets is really bankrupt," argues Cornell University's Carl Sagan. The shuttle-imposed limitations of a low-orbit space station would make it a stepping stone to nowhere without the concurrent development of "space tugs" or second-generation shuttles capable of reaching high orbit. "A case has not been made for a permanent human presence in low orbit with this technology," says Sagan flatly.

Critics contend that most of its proposed functions could be performed with equal efficiency and vastly greater economy by machines instead of people. Proponents of manned spaceflight argue that robots aren't smart or flexible enough to do everything that needs to be done in space; no machine can replace a good man (or woman) with a screwdriver. On a recent shuttle flight, an astronaut saved a photographic experiment by doing a delicate repair job on a jammed film drive. On the same flight, though, another astronaut ruined a crystal-growing experiment when he accidentally kicked the "off" switch.

The cost of maintaining human expertise in space is enormous. It now costs about $1,000 a pound to deliver a shuttle payload to low orbit—a price that underwrites the expense of life support and redundant safety systems for the astronauts. It is as if the price of a washing machine included room and board for the Maytag repairman!

NASA and White House spokesmen steadfastly deny that the Reagan space station proposal is mainly a response to Soviet space activities. Still, the proposal came just a month after the release of a Congressional Office of Technology Assessment report which concluded that the Soviets, with their *Salyut* spacecraft, already have what amounts to an operational space station.

"The Soviet space program is really quite a ways behind what we're capable of doing today," says Bruce Abell. But the Soviets are developing their own reusable shuttle. They have far more experience than NASA in studying the long-term effects of weightlessness. And they are working on a new generation of heavy-lift expendable boosters and a heavy-lift shuttle that could have twice the payload capacity of the American shuttle.

"The Soviet space station program," according to the OTA report, "is the cornerstone of an official policy which looks not only toward a permanent Soviet human settlement of their people on the Moon and Mars. The Soviets take quite seriously the possibility that large numbers of their citizens will one day live in space." Many observers expect that the Russians will attempt a manned mission to Mars some time in the 1990s.

The Soviet Union's space station seems to fit well into its long-term plans for space, while the U.S. station seems more in line with America's "space spectacular" philosophy. As indicated earlier, the low-orbit station the administration is planning simply does not make good sense, given the limits imposed by technology.

There is, however, one circumstance under which such a space station could be justified. That is a station built in cooperation with other spacefaring nations, including the Soviet Union, Japan and the countries of Western Europe. A multinational station would not eliminate the drawbacks inherent in any small, low-orbit facility. But it would be cheaper for the United States, thus saving funds for other ventures. It would avoid duplication—a problem that is going to become greater as more nations get into the space act. And it undoubtedly would produce side benefits that are difficult to forecast. By bringing together the world's best scientists and engineers, a multinational station would spin off new ideas and approaches to the challenge of space.

The administration seems receptive to internationalizing the station. NASA officials report that as much as one-fourth of the cost could be borne by Western Europe, Japan and Canada.

European participation in the space station would prevent the Pentagon from hopping aboard later, after the bills have been paid, as it did in the shuttle program. ESA is a purely civilian program, and its members include neutral countries Ireland, Austria and Switzerland. ESA participation would, therefore, preclude a military role for the station.

Inviting the Soviet Union in would provide an extremely important symbolic role for a multinational "Earthport." It would symbolize a commitment to a peaceful use of space, would help to relax East-West tensions and would defuse some of the Soviet and Amer-

The Space Station
by Hans Mark

I first read about a space station forty-two years ago in *Rockets Through Space—The Dawn of Interplanetary Travel* by P. E. Cleator (Simon and Schuster, New York, 1936). Cleator describes a space station proposed by the German engineer Guido von Pirquet, and on page 128 he says: "Could the scheme be put into effect, a spaceship would be able to escape from the Earth with a plentiful supply of fuel. The ship would arrive at the outward station with its fuel supply all but gone. But after refueling, it would be in a position to proceed spacewards with the expenditure of comparatively little fuel. Indeed, so great are the possibilities of the space station that von Pirquet is of the opinion that the achievement of interplanetary travel, even ultimately, must depend upon the construction of such a station."

For those of us interested in planetary exploration, this statement puts the case for a space station as well as can be done today. A space station is an essential staging base for exploratory trips to the planets that people will make sooner or later. Von Pirquet made the calculations fifty years ago as well as we can today.

Why is there controversy over the permanently manned space station proposed by the President last January? One point at issue is whether people should go to the planets or whether exploration should be done only with machines. Those of us with technical backgrounds are comfortable with machines, but we make a mistake if we think that things done with machines have anywhere near the impact that human explorers create. Time and again, our political leaders have recognized—correctly, I believe—that the only way to create a vision of what the future holds is to relate this vision to the actions of individual human beings. This is why the astronauts remain the central figures in our space exploration program.

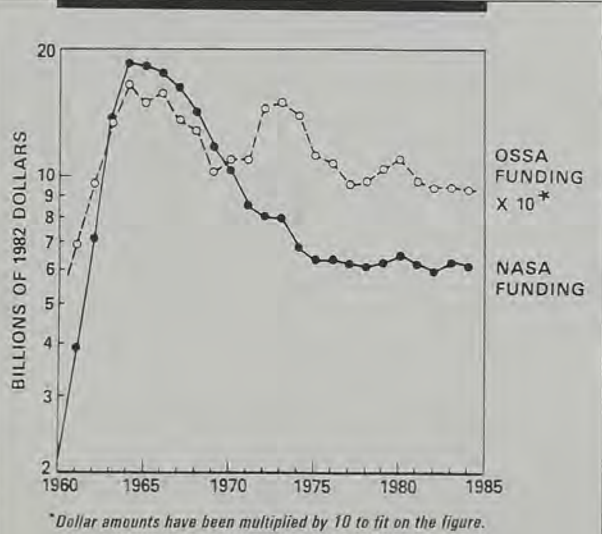
The second complaint against the space station proposal is that it will take money away from scientific research. This argument is precisely the same one that our military leaders have made in opposing a space station. Both the scientists and the military seem to believe that the nation's space program is a zero sum game and whatever is spent on a space station by NASA will not be spent on scientific or military programs. The facts do not support this contention. The figure shows the funding history of NASA's Science and Applications program compared to the total NASA budget since 1960. Since 1970, the Office of Space Science and ican paranoia about a "star wars" mission for future space stations. That, in itself, might justify the price.

Now, rather than later, is the time to think about the political, scientific and commercial opportunities that a constructive use of space offers. We need to do this thinking before we commit ourselves to another round of expensive, and increasingly dangerous space-racing. The decisions we make today will determine the human future in space, not just for the next decade, but for the next century and beyond. This may well be our last chance to give life and meaning to our own inspiring rhetoric: "We came in peace, for all mankind."

[Reprinted with permission/*Washington Post*, April 1, 1984]

Applications (OSSA) program has been a constant fraction (between 15 percent and 18 percent) of NASA's total budget. The upward excursion in 1972–73 was caused by *Viking* and that in 1977–78 by *Voyager*. (The Applications program is included because most of it is basic research in atmospheric and ocean sciences and Earth observations.) Furthermore, the maximum scientific spending by NASA coincided with NASA's peak spending in 1965 during the *Apollo* program. Far from being a zero sum game it turns out that space science budgets increase when NASA's budget increases and vice versa. It is most important for those interested in space science and planetary exploration to recognize this point.

I started with a quote from P. E. Cleator's book so let me finish with one. This book, by the way, is not a children's book but a serious assessment of rocketry in the 1930's. On page 156, Cleator reports on the flight of a rocket launched by the American Rocket Society. After describing some problems, Cleator says: "This done, and the other necessary alterations made, the rocket was shot on September 7, 1934. It fired for fifteen seconds, attained an altitude of 382 feet and achieved a speed of more than 60 miles an hour." If Cleator could dream of space stations with only the modest technical achievements of the day to back him, surely we can dream of men walking on Mars in the next fifty years after all we have done during the last. As an organization dedicated to further the "adventure of planetary exploration," I hope that The Planetary Society will support the space station as the first real step in that direction.



*Dollar amounts have been multiplied by 10 to fit on the figure.

Science and a Space Station
by T. M. Donahue

Beginning in the summer of 1982, the Space Science Board of the National Academy of Sciences engaged in a dialog with NASA on the advantages and disadvantages of a space station. Late in 1983, responding to requests from various elements in the government, the Board formulated two position papers. One report addressed the question of whether the space station then being considered would significantly enhance the space science missions it proposed to support. The missions in question were designed around expendable launch vehicles, the space shuttle, and its upper stages now being developed, so it was hardly surprising that our answer was negative. Since it would take at least 20 years to mount all of the missions now planned, we were led to make our much-quoted statement that we saw no scientific need for this space station during the next 20 years.

However, we also made it clear in our other report that we did not believe that the decision to build a space station would be made on grounds of space science and applications alone. And that is the case. The administration has not claimed that a space station must be built because science needs it. The issue of whether or not there will be a space station has been settled; it is now up to us to ensure that it will be designed for the greatest possible usefulness to science. It is also up to us to make sure that the lessons of the past are learned and that science does not suffer again as it did during the space shuttle development.

To the first end we are responding to a request from James Beggs, Administrator of NASA, to identify the major science issues to be answered with space missions (not just those tied to a space station) during the two decades beginning about 1995. We will start work this August.

To the second end we are emphasizing the need to keep existing launch and support facilities in place while a space station is developed. We strongly believe that we must proceed with the present set of science missions and not trust in the capability of a space station to do them better. This would repeat the shuttle experience when the premature disappearance of expendable launch vehicles caused us to spend hundreds of millions of dollars to delay missions instead of launching new ones. The missions now designed address important science questions, and we must get on with them. The pressure to delay some of them to accommodate them to a space station will grow inexorably. You can count on it. And you can also count on the Space Science Board to resist as long as I have any influence on it. Care will also have to be taken to accommodate missions that do not lend themselves to a space station because of the orbit needed or other requirements. We shall also have to avoid shifting priorities in favor of missions that are compatible with a space station.

Science must also play an integral role during space station planning, with NASA building a strong scientific component into its space station organization. A very positive development is NASA's declared intention to protect its programs such as space science from possible space station budget overruns by not insisting on a firm date for deploying the station.

I realize that this presentation has a negative tone. That is unavoidable, given the trauma of our experience with the shuttle. But we are heartened by the disposition of NASA, the President's Science Advisor and Congress to insure healthy space science during the space station era. We can exploit a space station for science now that it seems we are going to have one. We shall certainly try.

Names on Dista

"Once, from eastern ocean to western ocean, the land stretched away without names. Nameless headlands split the surf; nameless lakes reflected nameless mountains; and nameless rivers flowed through nameless valleys into nameless bays.

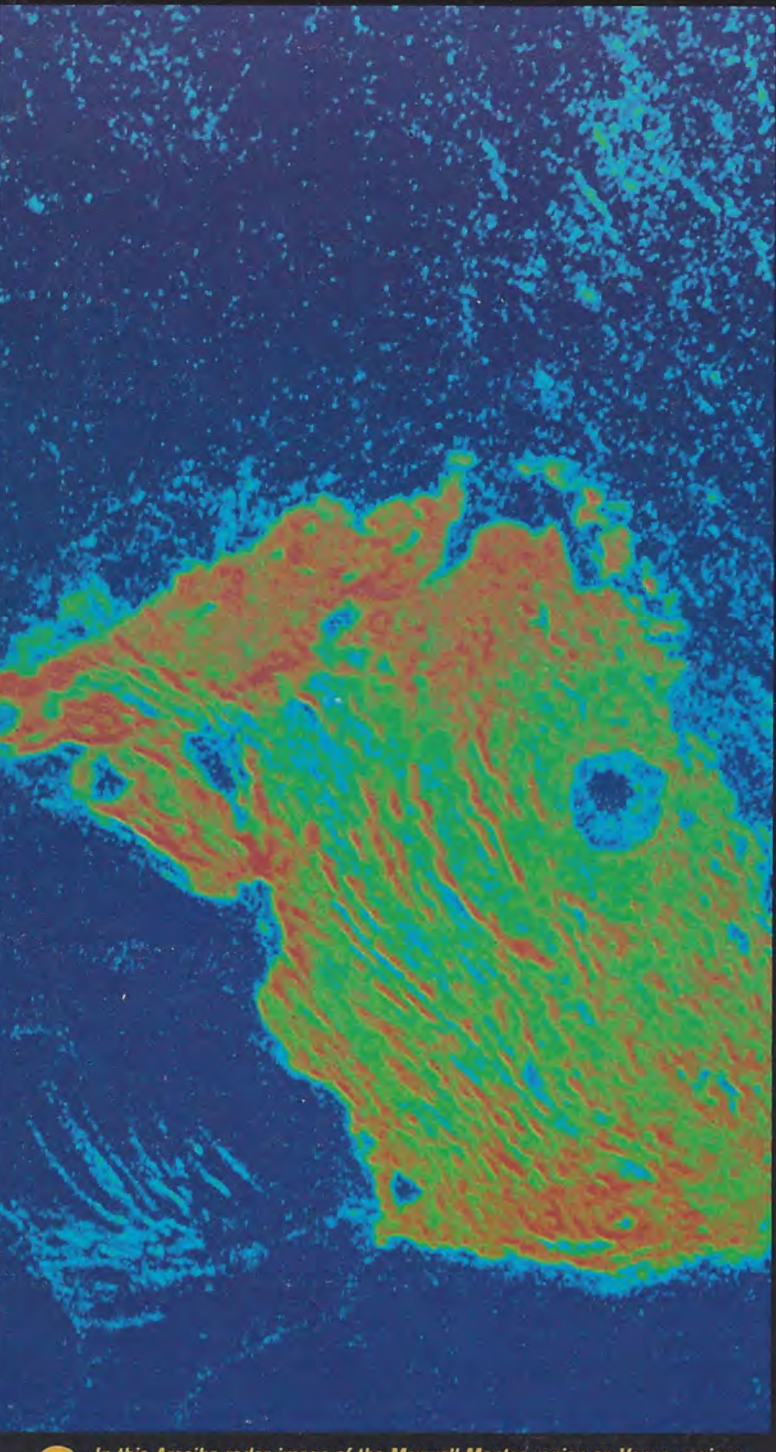
"Men came at last, tribe following tribe, speaking different languages and thinking different thoughts. According to their ways of speech and thought they gave names, and in their generations laid their bones by the streams and hills they had named. But even when tribes and languages had vanished, some of those old names, reshaped, still lived in the speech of those who followed."

So begins George R. Stewart's book, *Names on the Land*. Stewart, the California historian and novelist better known for *Storm, Fire* and the science fiction classic *Earth Abides*, considered *Names on the Land* the finest of his own creations. In it he tells the story of the words on the map of America: Cape Canaveral (one of the oldest names on the continent), Dead Mule Canyon, Minnehaha Falls and hundreds of other colorful names that early explorers and later builders casually bestowed on our land.

Naming the newly discovered is in the heart of science and indeed of civilization. So far as we know, humans are the only earthly species to originate names for things. But the association of an object and a symbol (easily taught to many other animals) is so fundamental to the intellect that it will be no surprise if other intelligent beings, here or elsewhere, are found to create it too.

In this article we briefly explore the naming of places and things in the solar system. In ancient times, vanished Chinese and Babylonian names existed for what we now call planets ("wanderers" in Greek). The nine planets, with one barbaric exception, now bear Roman names. After classical times, the next outburst of naming came with the Renaissance and the invention of the telescope. Galileo's obsequious title, "The Medician Stars," for the four large moons of Jupiter did not last; they became known as Io, Europa, Ganymede and Callisto, named for consorts of the god Jupiter. In honor of their discoverer, they are collectively known as the Galilean moons.

Meanwhile, telescopic explorers of the Moon were naming everything in sight. Even the naked eye can distinguish the light lunar highlands from the great dark lava plains. In the telescope, the smoothness of the plains becomes obvious and it is no wonder that they came to be called *maria* or seas. Their names evoke the aspirations of humans who lived centuries before any possibility of travel to the Moon, but yearned anyway to be there: Ocean of Storms, Bay of Rainbows, and Seas of Clouds, Rains, Serenity, Tranquil-



In this Arecibo radar image of the Maxwell Montes region on Venus, regions of higher and lower radar reflectivity (which may correlate with surface roughness) are shown as different false colors. The circular feature, nearly 100 kilometers across, may be an impact basin or a volcanic caldera. It is called Cleopatra Patera (the word "patera"—Latin for saucer—has been applied to large, low Martian volcanos, but here does not necessarily denote a volcanic origin). IMAGE: JAMES HEAD, BROWN UNIVERSITY

Gods and goddesses of the the Mediterranean Sea are satellites. A few astronome have memorials there.

...ant Worlds

by James D. Burke

...ancient civilizations that rose and fell around ...remembered on Ganymede, the largest of Jupiter's ...s, such as Ganymede's discoverer, Galileo, also ...AGE: JPL/NASA

This portion of the Shakespeare Quadrangle of Mercury, as mapped by J. E. Guest and Ronald Greeley of the United States Geological Survey, shows an area about 1000 by 1600 kilometers. The colors portray several geologic units—areas differing in visible properties and relative age. MAP: UNITED STATES GEOLOGICAL SURVEY

ity, Nectar, Crises, Dreams. In telescopes hundreds of other features, mostly giant craters, appeared and were named on a succession of elaborate lunar maps made during the seventeenth and eighteenth centuries and culminating in the great lunar atlas of 1837, made from drawings by observers at Berlin and Athens. There followed a long period of relatively little interest in the Moon. Then, on the eve of lunar flight, another great atlas, this time a photographic one, was produced under United States Air Force auspices by Gerard P. Kuiper and colleagues at the Universities of Chicago and Arizona.

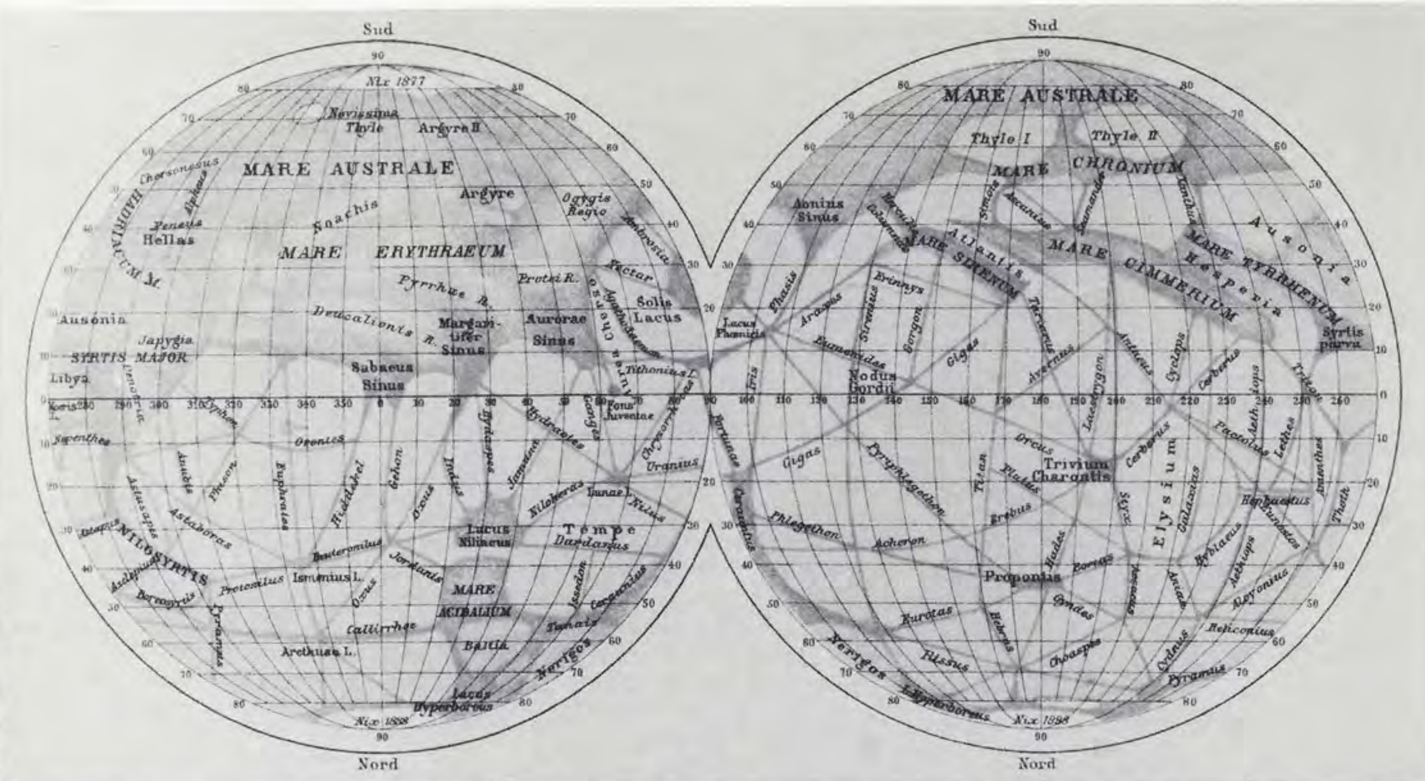
Many lunar craters are named for famous people: Aristarchus, Hipparchus, Archimedes, Plato, Ptolemy, Copernicus, Kepler and hundreds of other humans have magnificent memorials on the Moon. In 1959, when *Luna 3* returned the first images of the Moon's far side, the tradition continued with Russian names, including Tsiolkovsky and Lomonosov. After 1966, the atlas of named features on near and far sides expanded tremendously as American lunar orbiters mapped the whole Moon in detail.

Fortunately, by the time exploring spacecraft began to reveal the new territories to be named, an arrangement for accepting and placing names on maps was already in being. The International Astronomical Union had taken upon itself the duty of coordinating maps of the heavens, standardizing celestial reference systems and cataloging the names of objects. IAU commissions were set up to agree on name sets for planets, moons, asteroids and comets.

There was, of course, some political wrangling, serving mostly to prove that geographic names are important emblems of a nation's character and achievements. In the main, however, the negotiations were amicable and productive; one mark of their success is that the source list was greatly broadened to include nomenclature from all of Earth's races and tribes, instead of just the Europeans who began the naming process.

Another good outcome was that proposals for rigid standardization failed. Nobody told the mountain men how to lay down names across Wyoming: as a result, trans-Atlantic airliners cross the Crazy Woman radio checkpoint on their way to California, while the Union Pacific sings with the rhythm of Cheyenne, Laramie, Rawlins and Rock Springs. Similarly in the solar system, no single naming rule prevails. However, there is a general structure: a preponderance of descriptive Latin names on Mercury, classical female names on Venus, people's names on the Moon, mythological names on Mars and the outer planets' satellites, and at home, the wonderful rich babel of Earth.

When *Mariner 10,* launched in 1973, revealed the Moonlike surface of Mercury, mapping began with the establishment of a coordinate system and the naming of large quadrangles: Shakespeare, Tolstoi, Beethoven, Michelangelo, Bach and others, within which craters and other features were named either descriptively (such as



MAP: COURTESY OF G. DE VAUCOULEURS

ABOVE: Antoniadi made this map of Mars in the late 19th century. Mariner *and* Viking *images confirmed the reality of many of the large features named by the old astronomers. Some of these features change with the Martian seasons as darker and lighter surface materials are moved around by winds.*

BELOW: Typical of maps made during the first century of the telescope, this 1651 portrayal of the Moon shows the nomenclature established by Hevelius, Grimaldi and Riccioli—many of whose feature names are still in use today. MAP: VATICAN OBSERVATORY

Caloris basin, for the planet's hottest region) or for noted people from the many nations of Earth.

Naming the vast land area of Venus began prosaically in the early 1960's, when Earth-based radar, probing for the first time, penetrated the planet's clouds and revealed a few surface regions with higher electromagnetic reflectivity than their surroundings. One of these was named Alpha Regio and was taken as the origin for measuring longitudes on Venus. Another bright region was simply called Beta Regio. Then, as the radar technique improved, a huge, rough, mountainous area was delineated and named Maxwell, for the Victorian physicist who elucidated the nature of electromagnetic waves. With continuing improvements in the Arecibo radar and its data processing system, the Maxwell Montes region has been found to have long, curving bands of high and low reflectivity on a scale similar to that of the Appalachian mountains of Earth.

Meanwhile, in 1978, the *Pioneer* Venus Orbiter began mapping Venus' topography by means of a radar altimeter, and gradually the whole of the planet's cloud-shrouded surface was revealed. Broad, gently rolling low plains, great rifts, high continents, ancient craters and huge volcanos came into view. As the map unfolded the IAU commission began its naming work. In keeping with the planet's own classical name and its aura of feminine mystery, the new names were largely female: Aphrodite, Ishtar, Freyja, Guinevere and Sacajawea now have their monuments upon our sister planet's map, and

IMAGES: JPL/NASA

Many painters, playwrights, poets and other earthly artists now have monuments on Mercury. The planet's surface is covered with the marks of asteroid and cometary collisions, providing scientists with a wealth of craters to name. These photomosaics were compiled from high-resolution images taken by Mariner 10 *on its incoming (left) and outgoing (right) encounters.*

the list will surely be extended as the present Soviet radar orbiters, *Venera 15* and *16*, and the 1988 American Venus Radar Mapper complete the mapping of the planet.

Some of the loveliest names in the solar system, evocative of the noble dreams and also of the nightmares of humanity, lie upon the great deserts, canyons and mountains of Mars. Peering intently through telescopes at the features vaguely visible from Earth, astronomers named Elysium, Amazonis, Memnonia, Tharsis, Chryse, Hellas and other large regions, and they selected a distinctive small, dark feature as the origin of Martian longitudes and named it Meridiani Sinus. Then *Mariner 9* in 1971–72 and the *Viking* Orbiters in 1976–78 opened up the entire planet to our eyes and the IAU commission gave hundreds of additional names in Latin, preserving the classical tradition. Also features were named on the two small Martian moons, Phobos (fear) and Deimos (panic), which are themselves named for the war god's attendants.

Then there are the asteroids. The first few to be discovered were named for goddesses and gods. As their number grew into the hundreds, they were just numbered serially, even if already named (such as 81 Terpsichore, 129 Antigone, 2101 Adonis) and as thousands more small ones now seem likely to be found, they are temporarily numbered by a coded date of discovery (such as 1982 DB) and then named by their discoverers for ideas, events or friends.

On Jupiter and Saturn, since we see only atmospheric features, names are merely descriptive—North Equatorial Belt, Great Red Spot, and so on—in the humble tradition of earthly names such as Blue Ridge or Roaring Run. Similarly, Saturn's sets of rings are just labeled A, B, C and so on; the two major dynamical gaps in the rings are named for their discoverers, Cassini and Encke. But on the satellites of the giant planets, fanciful names again abound; Io's active volcanic landscape is spattered with mythological names, including ones suggestive of fire and brimstone. Ganymede's ancient, cobwebbed face carries names from old Mediterranean and Levantine civilizations, as well as a few serene reminders of earthbound astronomers who knew the huge moon only as a point of light. Callisto bears names taken from Norse legends.

Titan, because of its thick clouds, will have no names until it is seen by radar—and even then, it may turn out to be covered by a featureless ethane ocean. But the other satellites of Saturn—Mimas, Enceladus, Tethys, Dione, Rhea, Hyperion, Iapetus, Phoebe and several more small ones discovered by *Voyager*—all have visible surfaces with strange features that are beginning to be named.

Onward and outward, fancy reigns again in the lovely names of Uranus' five known moons: Ariel, Umbriel, Titania, Oberon and Miranda. Neptune, Triton, Nereid, Chiron, Pluto, Charon—these mythical names complete the roster of known large bodies in the solar system.

So the first wave of name-giving has passed. Humans have planted the emblems of their history and of their dreams all across the Sun's dominion—even to the long-period comets which, in centuries to come, will all unknowingly bear their long-dead discoverers' names far out into the great spaces between the stars, there to wander, as may the two *Pioneers* and the two *Voyagers*, perhaps for endless ages after the civilization that named them is gone.

James Burke, our Technical Editor, is a Member of the Technical Staff at the Jet Propulsion Laboratory.

Choosing Names

The IAU Working Group on Planetary and Satellite Nomenclature sets categories from which they choose names for features on solar system objects. For example, the categories for the large satellites of Jupiter are:

Amalthea—names associated with the Amalthea myth;

Io—fire, thunder, sun, volcano and smith gods, and people or places connected with the Io myth;

Europa—places associated with the Europa myth;

Ganymede—dead astronomers who discovered satellites of Jupiter, names associated with ancient civilizations of the Near East;

Callisto—people, places and animals from myths of far northern ethnic groups, some Greek names associated with the Callisto myth.

Dr. Tobias Owen of the State University of New York at Stony Brook is a member of the IAU group. He offers these comments on the naming conventions established for the other outer planets and their satellites:

"We have established the following categories for the satellites of Saturn: Herschel is commemorated on Mimas since he discovered that satellite. As an English discovery, the Arthurian legend seemed an appropriate source for other names. Herschel also discovered Enceladus, but its surface is so mysterious that the Arabian Nights seemed a good choice. Tethys is associated with the sea, so we chose the *Odyssey* for it. Dione balances that with the *Aeneid*. Rhea is an Earth Mother; we used this as a theme to include names from as many world cultures as possible. Titan, covered by clouds, has no assigned names. Hyperion relates to the Sun and Moon. Cassini discovered Iapetus while working at the Paris Observatory, so we chose a French legend, *The Song of Roland*.

"The names of the satellites of Uranus, with one exception, come from spirits in English literature: Ariel, Titania and Oberon are from Shakespeare, Umbriel from Pope. The exception, Miranda, is a human character from *The Tempest*, which is also the source of Ariel. We plan to stay with Shakespeare for future names. Categories for feature names have not yet been established."

PALLAS REPORT

BY CLARK R. CHAPMAN

Last year, the second (or third) largest asteroid, 2 Pallas, passed directly between Earth and a distant star called 1 Vulpeculae. On the moonlit evening of Saturday, May 28th, the "shadow" of Pallas, as cast by the star, swept across the southern United States and northern Mexico. Because the star is bright enough to be seen by the naked eye, this occultation—the technical term describing the passage of one astronomical body in front of another—was an unusual and important event. Amateur and professional astronomers alike were out in force that evening, hoping to see the star blink out and thereby mark the edge of the shadow of Pallas. By piecing together observations from across the continent, astronomers hoped to determine the profile of Pallas to a far higher precision than any asteroid's shape had been measured before. There was a unique opportunity for ordinary citizens, armed with a small pair of binoculars, to participate in this scientific experiment from their own backyards. So I wrote an article in *The Planetary Report* soliciting help on a Planetary Society Pallas Project. Now, a year after this rare event, I want to share the joys and frustrations of Planetary Society members with you and let you know what a preliminary interpretation of all the data tells us about Pallas.

Using occultation data provided by many observers, including Planetary Society members (shown in red), Dr. Chapman was able to trace an approximate outline of the asteroid, Pallas.

Perhaps the chief lesson learned by most who tried to participate is that the life of an experimental scientist is not an easy one. Many members were outside the path of Pallas' shadow and failed to see a blink-out. Of course, we couldn't be sure exactly where the shadow would cross, so there were bound to be some disappointed observers. There had been the chance that a suspected natural satellite, or moon, of Pallas might cast a shadow somewhere on North America, in which case blink-outs far from the path of Pallas' shadow would have provided the dramatic first confirmation of the existence of an asteroidal satellite. As it turned out, no blink-outs were reliably observed that can be ascribed to the satellite. Either the satellite doesn't exist, which is a growing suspicion among some of the professional astronomers who had once promoted that possibility, or it simply was located on the other (southern) side of Pallas on the evening of May 28th, so that its shadow crossed the oceans and Gulf of Mexico unobserved. Such negative observations—"the star did NOT blink out at my house"—are important contributions to the database, but it can be disappointing to an observer to miss the rare event.

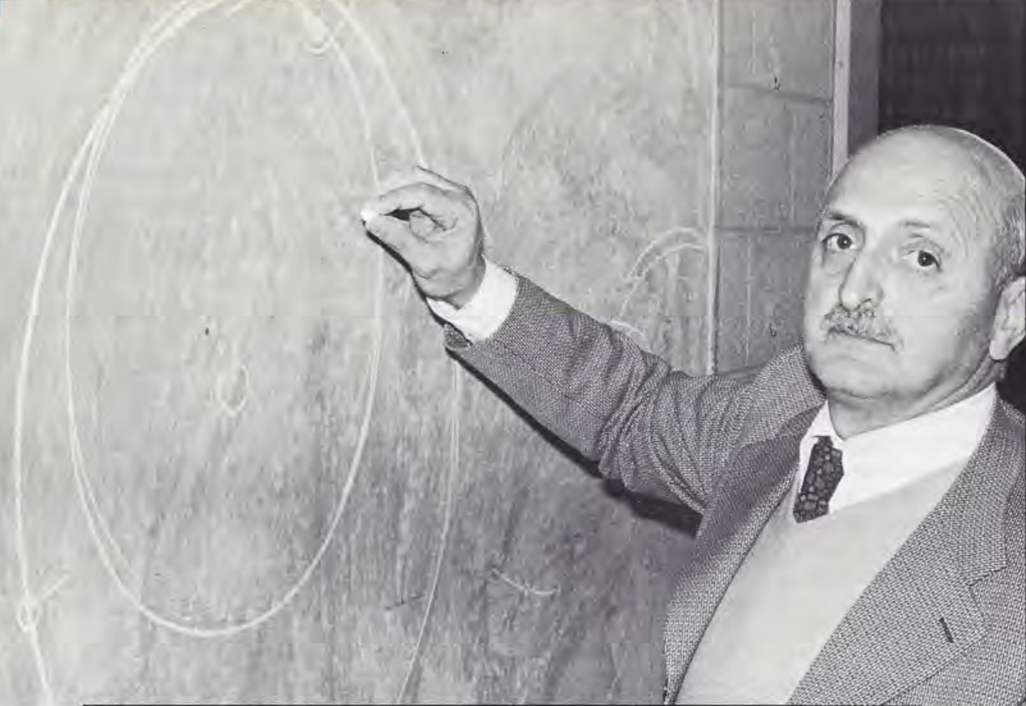
Still other observers were confounded by that bane of all astronomers, the weather. The anticipation and frustration of one Society member in Michigan was aptly expressed in his letter to us: "Ever since I received my copy of *The Planetary Report*, I made feverish but careful preparations to observe 1 Vulpeculae at its appointed time last night.... But as any scientist, amateur or professional, is painfully aware, frustration from a multitude of problems is unfortunately commonplace and this is especially true in observational astronomy. In our case, the weather decided not to cooperate. At 8 pm a frontal system moved into this part of Michigan and took the rest of the night to pass through, thereby frustrating our plans of the last month and a half! My brother and I thank The Planetary Society for the chance to participate in this endeavor in spite of our frustrations with the weather. We only hope that other Society members had better luck than we did." (I was also observing from Michigan myself, but it turns out that observers had to be south of a line joining Jacksonville, Dallas, and Tucson in order to be near or inside the path of Pallas' shadow.)

Although clouds in southern Florida, southern Texas, and northern Mexico obscured the southern quarter of the asteroid shadow, there were well over 100 successful observations by the combined team of professionals, amateurs and interested lay observers. The accompanying diagram shows the path of the star as observed by all successful observers, corrected for the time of passage of the shadow. The "hole" between the lines is the profile of Pallas. The lines shown in color are observations contributed by Planetary Society members. They include seven successful timings of the blink-out of 1 Vulpeculae plus four more observations that turned out to be "near-misses" and help to define the northern boundary of Pallas.

Planetary Society observers saw the occultation from Satellite Beach, Florida, from near Tampa, from the Florida panhandle, from the Houston area, from Central Texas, and from two locations in extreme southeast Arizona. The near misses were reported from the Dallas area and from northern Baja California. In addition, several dozen Planetary Society members reported marginal, negative or weathered-out observations from Arizona, Arkansas, California, Connecticut, Florida, Georgia, Illinois, Michigan, Minnesota, Oklahoma, South Carolina, Tennessee, Virginia, Washington and Quebec. The longest duration blink-out timed by a Planetary Society member was 44 seconds; the shortest was 17 seconds.

A preliminary value for the diameter of Pallas is 520 kilometers, with about 4 kilometer polar flattening. This makes Pallas somewhat smaller than had been thought, although its shape probably departs somewhat from a sphere and its broader face may have been averted at the time of the occultation. Still, it seems that Pallas is smaller than Vesta, so it has been demoted from second- to third-largest among asteroids. Some of the irregularities along the edge of Pallas may be real mountains, but others shown in the diagram may be inaccuracies in timing the blink-out. This profile (minus the clouded-out southern cap) represents by far the best picture we have yet obtained of an asteroid. Given the rarity of occultation events like this one, the next improvement may have to await a close-up fly-by by a spacecraft. I want to thank Planetary Society members for contributing to this important cooperative scientific experiment. I hope there will be future opportunities for other such Planetary Society projects.

Clark R. Chapman writes the "News & Reviews" column for The Planetary Report.



Giuseppe Colombo

1920–1984

by Louis D. Friedman

On February 20, 1984, Giuseppe Colombo died in his home in Padua, Italy. Professor Colombo had made extraordinary contributions to space science and exploration. The essence of his work was inventing ideas—ideas that to others seemed fictional, but he proved them practical.

I met Professor Colombo on my first day of work for the Jet Propulsion Laboratory. We were at a symposium about Mercury, discussing ideas for a new mission, *Mariner* Venus-Mercury. This was to be the first interplanetary mission to use gravity-assist to go to two planets with one spacecraft. We were all amused when, after the presentation of the planned mission to Venus and Mercury, Colombo asked, in his halting, apparently confused, gesturing manner, about the possibility of a *third* encounter—going back to Mercury! "That would just be luck," was the response. But Colombo persuasively argued that a third encounter would not be lucky, but could be ours for the taking. A few computer runs later, he was proved right.

I didn't know it then, but would learn over the next dozen years, that that was how a lot of people met Bepi, as he was everywhere called. In a meeting, he would make a seemingly absurd suggestion or ask an apparently irrelevant question, annoying the speaker or other participants because he seemed to be diverting them from the topic at hand. He would accept being put down, and then come back as if he had been sleeping and ask the same question—apologetically, but tenaciously—in a slightly different way. Then, slowly, the connection would be made as Bepi pursued the point until we saw the insight behind the suggestion.

This was Bepi's legacy. His insight could not only generate ideas, but could show how they were practical. This was a personal legacy to me as I came to know him and our families became friends. This was also his legacy to space exploration and to The Planetary Society—and its goals of encouraging new missions to new places. He was the quintessential ideas person. The Mercury re-encounter was but one idea. A few of the others are: a space communications platform, a new type of gravity-measuring device (the dumbbell gradiometer), a mission to fly into the Sun, solar sails, satellite tethers (the skyhook), tethers to launch payloads to other planets, and using the space shuttle external tanks for an orbiting platform.

Bepi was not an engineer, but a mathematician. His biography calls him a celestial mechanician—a great and apt term. Like a mechanic, he tinkered with celestial objects, manipulating concepts and formulas until something clicked. Professor George Field, former Director of the Harvard-Smithsonian Center for Astrophysics, described Bepi's work as "a form of play." It was true. His enthusiasm, tinkering and tenacious manipulation of mathematics to describe what he intuitively knew was possible made him one of the most creative contributors to the space age.

"Clever" was one of his favorite words, and he was. He figured out Mercury's rotation lock with its orbital period; Mercury rotates three times every two orbits. In recent years he applied his insight about resonance (relationships where the motions of objects become locked into periods that are integral multiples of each other) to Saturn's rings and satellites.

Bepi was a frequent traveler through Europe and the United States. He was a Distinguished Visiting Scientist at JPL, an

This fresco, painted by Giotto, depicts Halley's Comet hanging in the sky.

Associate and Staff Member at the Harvard-Smithsonian Center for Astrophysics, Hunsaker Professor at the Massachusetts Institute of Technology, Fairchild Professor at the California Institute of Technology, and a member of the Pontifical Academy of Sciences. He also served on several NASA and European space mission advisory groups. And that was only his consulting work—his primary work was done at the University of Padua, where he held two chairs. He traveled extensively to fulfill all his commitments, and it took a great toll on him and his family. But it made him a powerful force in international space programs.

He made significant contributions to the design of the Jupiter orbiter and probe mission, which became Project *Galileo.* Like Galileo, Bepi lived and taught at the University of Padua. He extensively studied Galileo's life and, as a member of the Pontifical Academy of Sciences, contributed to the Catholic Church's recent reassessment of the condemnation of Galileo. Before his illness, Bepi had agreed to write an article for *The Planetary Report* on the historical contributions of Galileo, Copernicus and Kepler.

Bepi was also involved in the European Space Agency's *Giotto* mission to Halley's Comet. In Padua, there is a famous fresco by Giotto that shows Halley's Comet. Bepi worked hard to convince ESA to send a mission to the comet, and he suggested that they name the mission after Giotto.

I had the pleasure of working with Bepi on the joint European-American design group for the Jupiter orbiter and probe. (ESA ultimately bowed out of the mission and the US pursued it alone as *Galileo.*) Bepi was ecstatic about the opportunities presented by the satellite tour around Jupiter. That he could continually reshape the orbits and encounters among Jupiter's satellites was a powerful stimulus to his innovative mind.

But our most exciting project together has yet to be realized. We devised a plan to send a spacecraft around Jupiter and then straight back into the Sun. Along with John Anderson and Eunice Lau at JPL, we wrote up our plan in a paper entitled "An Arrow into the Sun." Bepi's contribution to the concept was simplicity. If we ever sell that mission, I hope we name it *Colombo.*

The notion of using tethers in space may turn out to be his greatest invention. Imagine yourself in Earth orbit, he would say, gesturing excitedly, and you *raise* a tether like a pole for 50 or 100 kilometers. Then crank your payload up the tether, where it is now in a higher orbit but travelling at the same speed. Then release it! Because it's in a higher orbit but travelling at your speed, it will follow an ellipse that will take it to higher altitudes. What you would get is a free propulsion device for orbital transfer. (It did sound like something for nothing, but of course, it's not. You have to use power to raise the tether and push the payload up, but it can be solar power, not propulsion.) That idea still astounds me. It was a characteristic Bepi suggestion, simple in physical concept but imaginative in application.

In the same vein was his recent suggestion to use the shuttle external tanks to construct a space platform. Anybody could have suggested the idea, but Bepi came up with a clever dynamical technique for self-stabilizing the structure as it is being assembled. This makes the construction simple. The loss of Bepi now, while design is beginning on a space station, is profound.

Professor Colombo died of cancer. Although he had been ill for some time, his death was a profound shock to people at his "homes" in the US, the Center for Astrophysics in Cambridge and JPL in Pasadena. Even after his illness was detected, he had continued to work on both sides of the Atlantic. He consulted with colleagues in the US on the satellite tether several times before his death. Thanks to Colombo's initiative, a joint Italian-NASA tethered satellite project is scheduled to fly in 1987.

Louis Friedman is Executive Director of The Planetary Society.

SOCIETY NOTES

NAMING THE MAPPER, CONTINUED

The Venus Radar Mapper mission does not yet have a name. The Solar System Exploration Division at NASA is pleased, and a bit overwhelmed, by the many names for the project submitted by Planetary Society members in our "Name a Spaceship" contest. In fact, the number and variety of suggested names has prompted the NASA management to establish a policy for naming future missions. NASA officials have asked us to be patient while they formulate the policy. (A peek at the policy and the names being considered indicates that several of our entries are serious candidates.) We hope to be able to announce the new name for the Venus Radar Mapper soon.

NEW MILLENNIUM COMMITTEE

David Brown, President of Time Energy Systems, Inc., has been named Chairman of The Planetary Society's New Millennium Committee by our Board of Directors. (Long-time Society members may remember that Mr. Brown donated our first computer, an Apple.) The New Millennium Committee has been formed to secure large donations that will enable us to undertake long-range programs that may not produce results until the 21st century. These programs could include the search for extraterrestrial intelligence, human missions to Mars and near-Earth asteroids, and our science education program. Mr. Brown has been a generous donor to the Society and we appreciate his efforts very much.

Persons interested in the New Millennium Committee should write to: Mr. David Brown, New Millennium Committee, 2900 Wilcrest Drive, Suite 400, Houston, Texas 77042.

APPEALING FOR THE FUTURE

We received many interesting responses to the letter from our Vice President, Bruce Murray, about the Society's new education program. We have raised enough funds to help us launch the program and seed development of new classroom materials. Support came from many quarters: the Aerospace Corporation donated $1,000, a United States Senator on the Education Committee is looking into the possibility of our doing a pilot program in cooperation with the government, a national foundation has asked for details of the program, and many educators offered ideas and help. With the donations from members, we have hired a consultant and begun work on a sample package to be tested in the coming school year.

Those of you who wish to contribute to our education program may do so by writing to: The Planetary Society Education Program, 110 S. Euclid Avenue, Pasadena, CA 91101.

RAISING THE DUES

The Board of Directors, noting increased costs of printing, mailing and services since the Society's founding in 1980, has raised the annual dues for membership in The Planetary Society to $20. Dues for members outside the United States are now $25, or the equivalent in foreign currency. This is the first time we have raised dues. Donations from our members, given with renewals and for special projects, have allowed us to keep the Society's dues lower than those of most other membership organizations, and we intend to continue to keep the dues as low as possible, consistent with our standards of quality and service to members.

NEWS & REVIEWS

by Clark R. Chapman

I have written before in this column about the idea that a great asteroid impact about 65 million years ago wiped out the dinosaurs and many other species of life. I'll probably write about it again. There is something magically wonderful about the idea that everyone's favorite extinct creatures were done in by a cosmic catastrophe. But, during the last few months, the connections between life and the stars have gotten nearly out of hand. Anthony Hallam, commenting in the April 19, 1984 issue of *Nature*, wonders if Darwinian evolution itself has met its match. Rather than organisms competing with each other to carve out niches in a slowly changing environment, it is proposed that a cometary bombardment triggered by a "Death Star" may have spelled doom for countless species unable to cope with the disastrous and instantaneous consequences.

Death Star?

How did we get from a single asteroid impact—the idea put forward a few years ago by Luis and Walter Alvarez and their colleagues—to a "Death Star?" The history of science is replete with attempts to correlate terrestrial happenings with celestial phenomena. The Moon seems to affect human cycles, and has been linked to "lunacy" and rainfall, as well. But countless studies of correlations with the lunar phase, or with sunspots, or with the alignments of planets have bitten the dust in the face of rigorous statistical analysis.

Once again, correlations have been sought. First, David Raup and John Sepkoski, of the University of Chicago, studied tabulations of species extinctions and found what they claim is incontrovertible statistical proof of a 26-million-year cycle. Some physicists and astronomers were quick to note the similarity of 26 million years to the half-cycle of the Sun's vertical oscillation above and below the plane of the Milky Way galaxy. Some others invoked a small, faint "Death Star" in an eccentric orbit, revolving about the Sun every 26 million years. Such a star might stir up the comet cloud at the edge of our solar system and send a shower of comets into the inner solar system. Nearly all of the craters producing impacts on planetary surfaces are due to either comets or asteroids. Walter Alvarez and his associate Richard Muller then studied the reported ages of terrestrial meteor craters and found a 28-million-year cycle. All of the articles suggesting interpretations of the Raup and Sepkoski cycle are published in the April 19th issue of *Nature* along with two commentaries.

Are any of these ideas right? I think it is too early to tell. Statistics sometimes lie and there are other problems with these ideas. But it is a provocative notion, indeed, that evolution (including evolution of the human species) is governed by a giant, episodic target-shoot in the heavens.

Meanwhile, the debate goes on about the original Alvarez hypothesis. A commentary in the May 25, 1984 issue of *Science* about a scientific paper in the same issue says that there is now "compelling evidence" that the iridium-rich clay layer that the Alvarezes associate with the great Cretaceous/Tertiary extinctions is indeed due to impact. Microscopic analysis reveals the tell-tale signs of impact shock and there are even hints of high-pressure minerals that can be produced naturally only by an impact. There is still abundant dissent from the paleobiologists, who think they have evidence that the extinctions were gradual. Writing about mass extinctions in the ocean in the June, 1984 *Scientific American*, Steven Stanley criticizes both the "Death Star" idea and the simpler notion that a single impact produced near-instantaneous extinctions. It seems that the debate about celestial influences on the development of life on our planet have just begun.

Death Probe?

A contentious article in the June, 1984 issue of *Astronomy* asks the reverse question about whether human technology is about to affect the course of evolution of certain hypothesized extraterrestrial life. Linda Joan Strand is worried that the forthcoming *Galileo* mission to Jupiter may contaminate life evolving in the giant planet's atmosphere. *Galileo*'s top-priority goal is to drop an instrumented probe into Jupiter. After parachutes slow its 48-kilometer-per-second velocity, it is expected to descend beneath Jupiter's putative water clouds, into the warmer and denser atmosphere until the ever-increasing pressures ultimately crush the probe. In the meantime, instruments will relay back to Earth via the *Galileo* orbiter a wealth of data on the physics and chemistry of Jupiter's clouds and hydrogen-rich air. Strand reports that some University of Colorado scientists are concerned that the unsterilized probe or its parachute could release terrestrial microbes into Jupiter's atmosphere, thereby contaminating it.

Strict quarantine of spacecraft used to be a NASA policy. Indeed, the United States is party to an international agreement to ensure that extraterrestrial organisms do not contaminate us and to ensure that our spacecraft do not contaminate other planets. But given the current penny-pinching approach to planetary exploration, and in the psychological aftermath of finding Mars to be (apparently) lifeless, NASA is undertaking minimal sterilization of *Galileo*. The formal justification, apparently, is that the best scientific evidence makes it extremely unlikely that Jupiter harbors life.

Ms. Strand argues that the University of Colorado experiments point in the other direction. But the reader senses that her chief point is a philosophical one. We are sending the *Galileo* probe into a completely new environment—Jupiter's clouds—precisely because we do not understand that environment. So how can we be so sure that there aren't at least a few places in Jupiter's cloud-decks that would be hospitable to life? To require sterilization of the *Galileo* probe at this late date would be so costly as to ensure cancellation of the project. So it won't happen. Only time will tell whether or not the cost-saving measures of no sterilization were a good gamble in facing cosmic unknowns and the remarkable adaptivity of life.

Clark R. Chapman is taking a sabbatical from his Tucson base. He is working temporarily at the Institute for Astronomy of the University of Hawaii in Honolulu.

ONE OF THE GREATEST MYSTERIES of the solar system is Saturn's moon Iapetus, portrayed here by artist Michael Carroll. Its bright terrain is composed of dirty snow, while the dark areas probably contain complex organic molecules: They may be generated by ultraviolet light from methane-rich snow. This dark material seems to be welling up from the interior of the small moon, and its composition is still unknown.

Astronomical artist Michael Carroll specializes in the giant planets, and his paintings of Jupiter, Saturn and their moons often appear in science magazines. He lives in San Diego with his wife and new baby son and works at the Fleet Space Theater in Balboa Park.

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