The PLANETARY REPORT

Volume V Number 3 May/June 1985

A Publication of
THE PLANETARY SOCIETY

The Planetary Report (ISSN 0736-3680) is published six times yearly at the editorial offices of The Planetary Society, 110 S. Euclid Avenue, Pasadena, CA 91101

Editor, CHARLENE M. ANDERSON; *Technical Editor*, JAMES D. BURKE; *Associate Editor*, LYNDINE McAFEE; *Editorial Assistant*, DONNA STEVENS; *Art Director*, BARBARA SMITH

In Canada, Second Class Mail Registration Number 9597

COVER: This radar image, obtained by the Arecibo Radio Observatory, shows the large highland region on Venus called Ishtar Terra. Blue indicates smooth areas, while yellow and red areas are rough. Maxwell Montes, the bright area in the bottom left (east), is the highest area on Venus. Freyja Montes (center right, or north) and Akna Montes (center top, or west) are similar, but smaller mountainous areas. The large, dark blue area in the center is Lakshmi Planum, a high smooth plateau. (The curve along the right of the image is the edge of the data, not the limb of the planet.) Image: Donald B. Campbell, Ellen R. Stofan and James W. Head

Letters to the Editor

The recent issue of *The Planetary Report* concerning astrometry and planetary systems (September/October 1984) was marvelous! Each author was concise and easy to understand. Bravo to all those involved.

STUART L. FORT, *Indianapolis, Indiana*

Just a short note of opinion...if Owen B. Toon has not yet written a book for laypersons, then I sincerely hope it is in his plans. "Planets and Perils" in your January/February 1985 issue was one of the clearest and most beautifully written short articles I have read in years. There is a style and eloquence in his writing which is absent from so many scientific works, and it is refreshing to see such knowledge combined with such grace.

WENDY SINNOTT, *Chicago, Illinois*

Recent letters to the editor reflect concern about the industrialization of space and who is footing the bill. I believe space industrialization will help to achieve planetary exploration. Government may get us out there once or twice, but in the end private industry will take us out to stay. As Planetary Society members, we are active participants in the future of space exploration. The industrialization of space is linked closely to that goal.

PAUL D. BOSSLET, *O'Fallon, Missouri*

The goal of landing a human crew on Mars has the same glow and flaw that the *Apollo* Moon program had. The glow is the enormity of the task, the almost "ultimate" challenge. The flaw, however, is that it is a one-shot deal. Beyond the goal of landing, there is no other end. The flaw in *Apollo* was that no one asked, "What do we do after we've landed? How do we take advantage of what we've done?"

I suggest that rather than merely seeking a landing on Mars by the end of the century, we establish a permanent, peopled base on the Moon. A landing on Mars represents only a technological achievement, and not a particularly impressive one at that. A permanent settlement on the Moon represents both an achievement *and* a commitment to humans in space and to our continued existence.

HAL HORNE, *San Diego, California*

Many of today's scientists probably grew up as I did, devouring science fiction and daydreaming of distant stars. When *Sputnik* lifted off they were still children, but suddenly no longer dreamers. They were stuck in school when mature men were going into orbit and beating them to the Moon. Now they are scientists in their primes, filled with questions, ambitions and their childhood dreams. In twenty years their careers will slip away; in fifty years, their lives.

Unfortunately, there are few answers in space that cannot wait twenty or even fifty years. The taxpayer has his pictures and cares little about the chemistry. History has passed beyond the expensive, bold, lonely voyages of our Columbuses. Now is the time to expand our shipyards, build our galleons, establish our outposts and secure our supply lines. We must make room for the workers, the merchants and even the scoundrels. Only then will the New World become self-perpetuating and self-justifying.

Now is not the time to insist that millions be spent on narrow, scientific questions, no matter how tantalizingly close the answers. The long range view requires that we establish base camps like climbers on Everest. Quick runs to the summit only sap our strength and endanger the whole mission. We must capitalize on the public's present good will and establish a solid position in space. Our generation's unexciting role is to be builders; our children will be the new explorers. We can't squander their future.

BARRY ZIMMERMAN, *Hanover Park, Illinois*

I. S. SHKLOVSKII, 1916-1985

by Carl Sagan

IOSIF SHMUELOVICH SHKLOVSKII, one of the world's leading astrophysicists and the Soviet pioneer in the modern search for extraterrestrial intelligence, died in Moscow on March 5, 1985 following a massive stroke.

He was born in the Ukraine, the son of a rabbi, on July 1, 1916, a year before the Bolshevik Revolution, and matriculated in physics at Moscow State University in 1938. As a graduate student, in the wake of the Nazi invasion, he was relocated to Central Asia in an arduous railway journey that included a number of other students destined to play a leading role in Soviet science, including Andrei Sakharov.

After the war Shklovskii initiated a series of seminal scientific papers mainly concerned with the evolution of stars, the interstellar gas, and their interaction. His work embraced the solar corona; a theoretical analysis, before its discovery, of the 21-centimeter radio spectral line of neutral atomic hydrogen; the prediction that many interstellar molecules could be detected by radio astronomy; circumstellar masers; an analysis showing that planetary nebulae, enormous bubbles of interstellar gas, evolve from red giant stars; and the prediction, now widely accepted, that an x-ray star is a close stellar pair, one of which is a neutron star. Shklovskii's early fame came from his demonstration that the most prominent supernova remnant in the sky, the Crab Nebula, shines in ordinary visible light by synchrotron emission, generated by electrically charged particles accelerated in an intense magnetic field.

Shklovskii was always interested in the possible application of what he had learned about the stars to the planets of the solar system. He performed early studies on the evolution of planetary atmospheres, and later proposed that nearby supernova explosions may have played an important role in the evolution of life on Earth, perhaps triggering the extinction of the dinosaurs. (The prevalent view today, by contrast, is that the cause was the collision with the Earth of an asteroid or cometary nucleus. But his work was important in drawing attention to extraterrestrial influences on life on Earth.)

Shklovskii was a brilliant teacher, and many leaders of the Soviet program of planetary exploration, such as V.I. Moroz and V.G. Kurt, as well as many leading Soviet radio astronomers, such as N.S. Kardashev, were his students. Shortly after its founding, he became associated with the Institute for Cosmic Research of the Soviet Academy of Sciences, and until his death continued to play an inspirational role in Soviet missions to the planets.

I first made contact with Shklovskii on a quite different issue, the search for extraterrestrial intelligence. I had read some of his papers, including his supernova hypothesis on the extinction of the dinosaurs, and thought he might be interested in work I had been doing on interstellar communication. In 1962, I sent him a preprint of a paper of mine, and received with astonishing speed a reply that began with an old Russian proverb, "The prey runs to the hunter." Shklovskii had been writing a book on the subject of extraterrestrial intelligence and, pen in hand, was about to begin a chapter when my paper on the very subject of that chapter arrived. This led to a collaboration in which I arranged for his manuscript to be translated into English and added, at his suggestion, an equal amount of new material.

The book, published in 1966 in the United States as *Life in the Universe*, was favorably received and is still in print. The collaboration was entirely by mail, material sometimes arriving from Moscow with the censor's stamp of approval boldly affixed. As Shklovskii had for twenty years been refused permission to travel outside Eastern Europe, the book was published without our ever having met in person. The prospects for such a meeting were considered remote, but "the probability of our meeting," he wrote to me, "is unlikely to be smaller than the probability of a visit to the Earth by an extraterrestrial cosmonaut."

Nevertheless, the tides of domestic repression wax and wane, and in the late 1960s Shklovskii was granted permission to make his first journey to the United States. I had the pleasure of meeting him then, and many times subsequently in the United States, in the Soviet Union, and in Western Europe. His quick insights and unconventional trains of thought were exhilarating.

He had an infectious smile, and would grab your elbow or poke you in the lapel to make you pay attention to what was coming. His sense of humor was extraordinary, but he did not suffer fools gladly. I remember a meeting on communication with extraterrestrial intelligence in Soviet Armenia in September 1971, in which a Soviet scientist was proposing the somewhat daft thesis that the greatest scientific works — the triumphs of Newton, of Darwin, of Einstein — had all been devised at a time of solar maximum, when the Sun puts out more high-energy charged particles than on average. "Yes," Shklovskii remarked in an aside to me which could be heard throughout the conference room, "but *this* man's idea was invented in a deep solar minimum."

He received the Lenin Prize in 1960 — perhaps for work with military radio and radar systems — but was considered a maverick by the Soviet scientific establishment. While he was made a corresponding member of the Soviet Academy of Sciences in 1966, he was never advanced to full membership. I can remember a leading Soviet astronomer telling me in the middle 1960s, before I had met Shklovskii, that "fifty percent of what Shklovskii does is brilliant, but no one can tell which fifty percent it is." Indeed, Shklovskii was willing to entertain risky hypotheses, such as the idea that the motion of Phobos — the innermost martian moon, slowly spiralling inward — was due to Phobos' being hollow, and therefore having been constructed on a massive scale by some previous and now extinct martian civilization. Other more mundane explanations for the secular acceleration of Phobos have since been found.

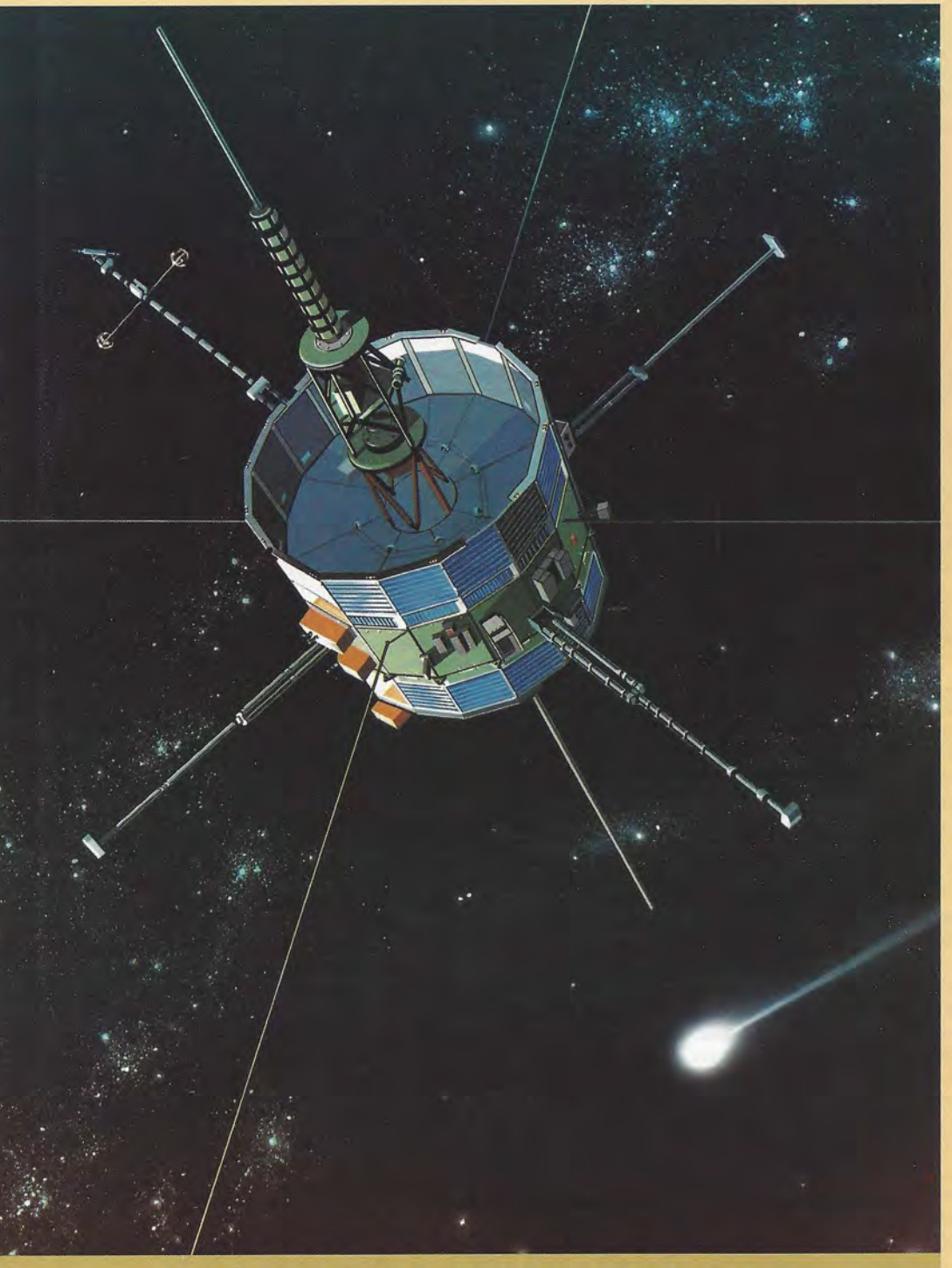
He was outspoken. As a Jew who had achieved considerable scientific distinction in the Soviet Union, he was outraged at signs of pervasive anti-Semitism in such matters as university admissions and academic promotions. He took to task Marxist theoreticians who argued that dialectical materialism required the other planets to be inhabited: he argued that these individuals did not understand their own Marxism, and that scientists must approach nature with an ideologically unencumbered and open mind. In the early 1960s he noted that "lasers of great power could provide a new type of weapon with extraordinary destructive capabilities," warned that the United States was spending millions of dollars each year and involving hundreds of corporations in such studies, and expressed the hope that such technology would be used only for peaceful purposes. (He refrained from commenting on any similar efforts in the USSR.) He publicly expressed delight that his

(continued on page 18)

Detour to a Comet

Journey of the International Cometary Explorer

by Robert Farquhar



On September 11, 1985 the International Cometary Explorer will encounter Comet Giacobini-Zinner. Painting: NASA

By the summer of 1981, it was fairly obvious that the United States would not be sending a space probe to Halley's Comet. Early plans to rendezvous with that comet using advanced propulsion techniques, such as a solar sail or ion drive, proved to be too ambitious. In the end, the dwindling NASA budget could not even support an inexpensive flyby mission.

Meanwhile, the Soviet Union, the European Space Agency and Japan were going forward with their plans to launch a total of five spacecraft toward Halley's Comet. It appeared that the United States would be the only spacefaring nation left at the gate in the Halley sweepstakes of 1985-6.

But despite the tight budget situation, there was still a glimmer of hope for a US spacecraft. Engineers at the Goddard Space Flight Center had a plan that would divert an existing scientific spacecraft from its station between Earth and the Sun to Halley's Comet. Launched in 1978, this International Sun-Earth Explorer-3 (ISEE-3) had already completed most of its primary mission objectives. ISEE-3 was ready and able to undertake new duties. And, the cost to send ISEE-3 to a comet would be less than $3 million, a bargain-basement price for a spacecraft mission.

The nominal cost was attractive, but a number of critics pointed out that ISEE-3's science payload had not been designed to study comets. However, several instruments could be used to measure a comet's plasma properties — a chief objective of cometary exploration.

A comet usually has two types of tails streaming out behind it: a dust tail, made primarily of small, solid particles; and a plasma tail, made of positive ions, protons and electrons. Dust tails are formed by the pressure of sunlight, while plasma tails derive their shapes from the solar wind and its magnetic field. (The solar wind is an ionized gas streaming out from the Sun.) The instruments aboard ISEE-3 could provide a better understanding of the interaction of the solar wind and a comet.

Trajectory analysts quickly identified a possible trajectory for ISEE-3 that would intercept Halley's Comet in March 1986, just after perihelion, or closest approach to the Sun. Unfortunately, the distance from Earth at encounter would have been about 150 million kilometers, beyond the communications range of ISEE-3. NASA abandoned its plans for a Halley's Comet mission, but it did not give up the idea of sending ISEE-3 to another comet.

An Alternative Comet

Fortuitously, there was also a possibility of redirecting ISEE-3 to a comet called Giacobini-Zinner. At the Giacobini-Zinner encounter, the spacecraft would be only 70 million kilometers from Earth, well within the range of its telemetry system.

Political factors also favored the Giacobini-Zinner alternative. ISEE-3 could encounter that comet on September 11, 1985, six months before the Soviet, European and Japanese spacecraft are scheduled to arrive at Halley's Comet. The United States could then be the first nation to obtain measurements inside the plasma envelope of a comet.

For several months, NASA pondered the mission. A few scientists with instruments on the spacecraft wanted it to continue its mission upstream from Earth. Others pointed out that ISEE-3, because it is not designed to study comets, would be limited to taking plasma measurements. But it was the only chance for the US to visit a comet in the near future. In the summer of 1982, the Space Science Board of the National Academy of Sciences strongly endorsed the mission and recommended that NASA approve it. Finally, in October, 1982, NASA gave permission to send ISEE-3 on to Giacobini-Zinner.

Giacobini-Zinner is not exactly a household name, even among astronomers, but it is an excellent cometary target. Originally observed by Michel Giacobini in 1900 and rediscovered by Ernst Zinner in 1913, it has been seen at eleven apparitions. It is very active for a short-period comet (one that frequently returns to the inner solar system), and sometimes exhibits irregular brightness variations. When near perihelion, Giacobini-Zinner's visible coma (a cloud of neutral gas and dust around the nucleus) is about 50,000 kilometers in diameter and its tail is about 500,000 kilometers long. Based on data from meteor showers produced when Earth passed through the comet's track in 1933 and 1946, Giacobini-Zinner is a rather dusty comet.

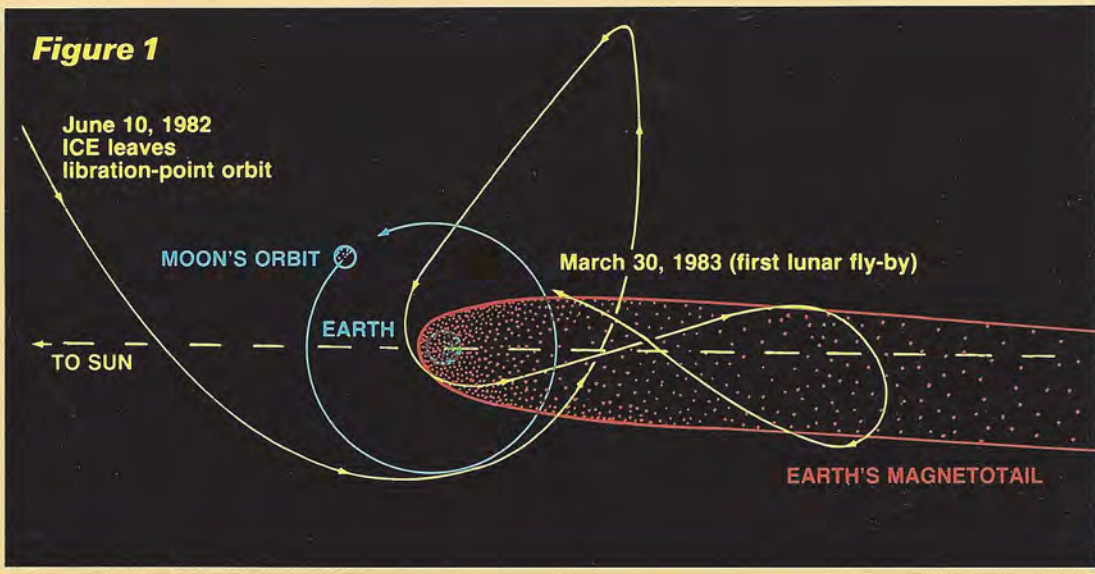
Libration Point Satellite

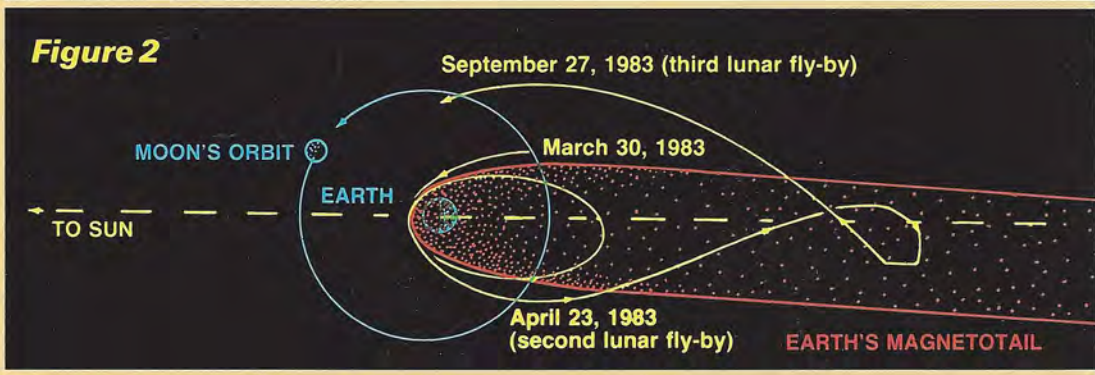
Long before it gained sudden notoriety as a comet probe, ISEE-3 had achieved some measure of fame as the first libration-point satellite. The Lagrangian libration points, named for the French mathematician Joseph Louis Lagrange (1736-1813), are places where the gravity fields of two bodies — in this case Earth and the Sun — interact in such a way that a third body can stay in their vicinity naturally or with only small propulsive impulses. The Trojan asteroids orbit near the L4 and L5 Sun-Jupiter libration points, 60 degrees ahead of and behind Jupiter in its orbit, and the Earth-Moon L5 libration point has been proposed as a site for a space colony.

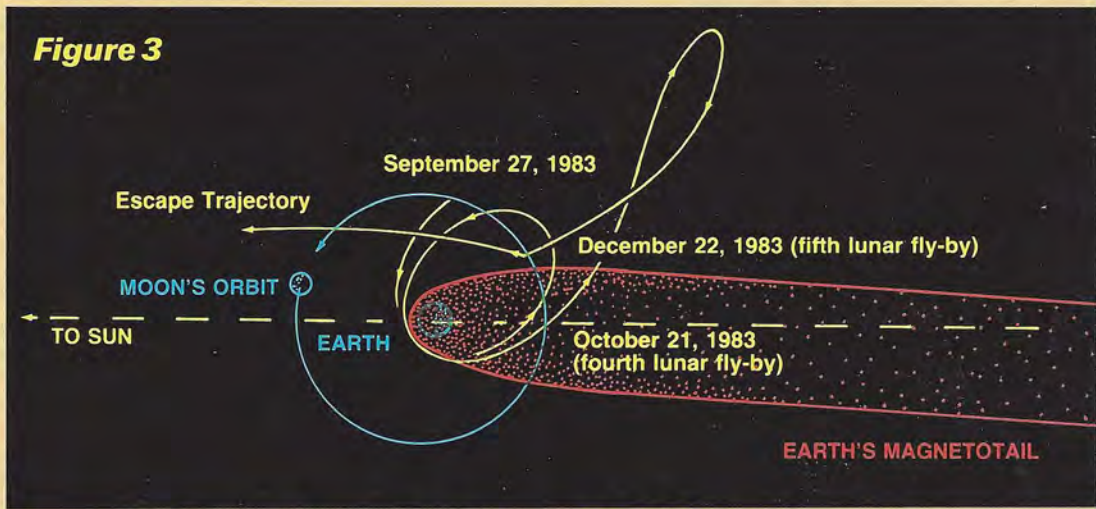
The ISEE-3 mission began on August 12, 1978 when a *Delta* rocket launched it toward the Sun-Earth L1 libration point. On November 20, 1978, the spacecraft was inserted into a "halo" orbit about the libration point. From this vantage, ISEE-3 continuously monitored solar-wind conditions upstream from Earth. It also served as an early-warning station for interplanetary disturbances that reached Earth's magnetosphere about an hour after they crossed the halo orbit.

The transfer of ISEE-3 from the halo orbit to an orbit intercepting Giacobini-Zinner was not straightforward. Although the spacecraft was equipped with a hydrazine propulsion system and had an ample fuel reserve, large maneuvers at perigee (its closest point to Earth) were not practical. The trajectory analysts

(continued on next page)







FIGURES 1-3: The complex flight profile that ICE has followed since it left its libration-point orbit and flew on toward Comet Giacobini-Zinner is shown in these figures. After investigating Earth's magnetotail and flying by the Moon five times, on December 22, 1983 ICE left for its rendezvous with the comet.
Charts: S.A. Smith

soon realized that the orbital energy needed for the craft to escape from the Earth-Moon system and reach the comet would have to come almost entirely from a lunar "gravity-assist." During this maneuver, the spacecraft would pass close to the Moon and receive an extra "push" from its gravity.

Flight Path

Figures 1-3 (page 5) depict ISEE-3's flight path from the time the spacecraft left its halo orbit in June 1982 to the beginning of its escape trajectory in December 1983. After five lunar swingbys, four propulsive maneuvers and eleven smaller navigational corrections, we accomplished this complex mission sequence.

An important scientific bonus of this flight plan has been the detailed exploration of the distant regions of Earth's magnetotail. Earth's magnetic field encompasses a region of space called a magnetosphere. When the solar wind strikes the magnetosphere, it pushes it out and away from the Sun, forming a magnetotail behind the planet.

Launched on July 1, 1966, *Explorer 33* had investigated this magnetotail out to 500,000 kilometers. The only measurements beyond that point, until ISEE-3, were obtained from single passes by *Pioneer 8* (launched December 13, 1967) at three million kilometers and *Pioneer 7* (launched August 17, 1966) at over six million kilometers. The ISEE-3 deep-tail measurements between 500,000 and 1.5 million kilometers have led to a number of new scientific discoveries about the interaction of the solar wind with Earth's magnetotail. This should contribute to a better understanding of the physics of cometary tails.

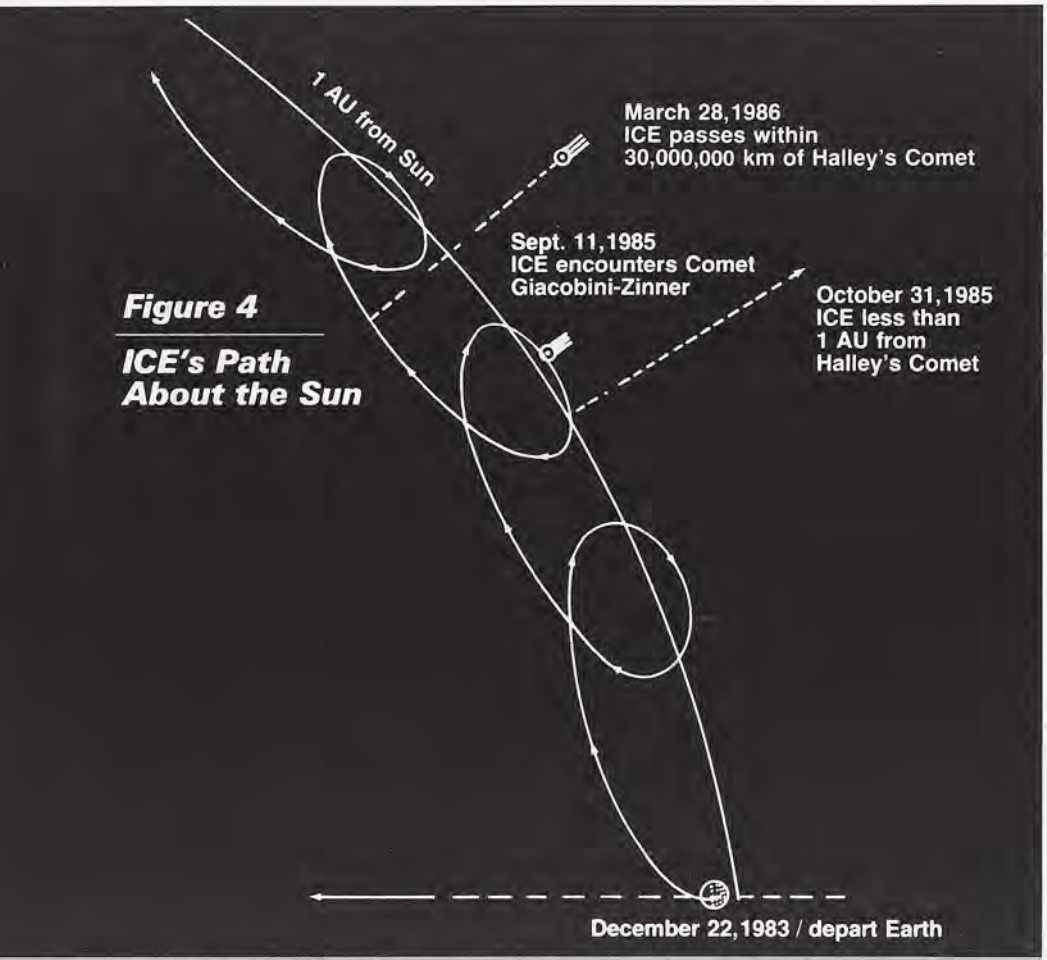


Figure 4

ICE's Path About the Sun

FIGURE 4: As it travels about the Sun, ICE will encounter Comet Giacobini-Zinner on September 11, 1985. Also, as shown in this chart, ICE will twice pass fairly close to Halley's Comet. The trajectory here appears to have a looping motion because it is plotted with respect to a fixed Sun-Earth line. (An Astronomical Unit, or AU, is the average distance from the Sun to Earth, about 150 million kilometers.)

On to the Comet

ISEE-3 had started on its convoluted trajectory on June 10, 1982. On December 22, 1983, it was scheduled to swing within 120 kilometers of the Moon for a gravity-assist that would shoot it on to Giacobini-Zinner.

As it passed behind the Moon, ISEE-3 would enter the cold shadow where no sunlight could fall on its solar panels, which provide energy to heat the spacecraft. ISEE-3's battery was long dead, so there was a danger that without heat the spacecraft's hydrazine fuel would freeze while it was behind the Moon. A few hours before the spacecraft was to enter the shadow, project managers turned most of the equipment off and turned the heaters up, trying to warm ISEE-3 before the swingby.

Transmissions ceased as the spacecraft entered the shadow. Mission analysts calculated the time ISEE-3 was expected to emerge from behind the Moon, and they knew it would take a few minutes for the spacecraft to warm up again. Still, they were relieved when signals from the spacecraft finally started coming in.

The lunar swingby catapulted ISEE-3 into orbit about the Sun. The little spacecraft was on its way to meet a comet. Immediately following the maneuver, NASA announced that it was changing the spacecraft's name to the International Cometary Explorer (ICE).

Encountering Giacobini-Zinner

ICE will encounter Giacobini-Zinner as the comet crosses the ecliptic plane (the plane determined by the orbit of Earth about the Sun). Its heliocentric trajectory is shown in Figure 4 (opposite). Our present plans call for the spacecraft to fly through the comet's tail about 10,000 kilometers from the nucleus.

At 7:00 am Eastern Daylight Time in the US on September 11, 1985, ICE will make its closest pass to the nucleus. Mission planners chose this time to maximize coverage of the intercept, for the Goldstone and Madrid facilities of NASA's Deep Space Network (DSN) can then simultaneously cover the transmissions, aided by the giant antenna of the Arecibo observatory.

After leaving Giacobini-Zinner, ICE will continue in its orbit, twice passing between the Sun and its once-considered target, Halley's Comet. On its first pass, Halley's Comet will be rather distant, but on the second pass on March 28, 1986, ICE will come as close as 30 million kilometers to the comet. The spacecraft will provide data on the solar wind upstream from Halley's Comet; at the same time, Earth-based telescopes will observe the effect of the solar wind on the comet's tail. These measurements will help us determine the cause-and-effect relationship of the solar wind and cometary tails.

Sometime in 1988, ICE will be too far from Earth to be heard by even the largest antennas of NASA's Deep Space Network. But this may not be the end of its mission. ICE will return to the vicinity of Earth in July 2012. Mission designers have planned a lunar gravity assist maneuver to recapture the spacecraft into an Earth orbit. From this location ICE could be recovered and eventually retired to the National Air and Space Museum of the Smithsonian Institution.

Robert Farquhar discovered the complex trajectory that is carrying ICE to its rendezvous with Comet Giacobini-Zinner. He works at Goddard Space Flight Center in Greenbelt, Maryland.

WEAPONS IN SPACE

IMPLICATIONS FOR THE CIVIL USES OF SPACE

On January 12, 1985, The Planetary Society sponsored a symposium, "The Potential Effects of Space Weapons on the Civilian Uses of Space," in cooperation with the American Academy of Arts and Sciences, at the National Academy of Sciences auditorium. Dr. Bruce Murray, Vice President of the Society, moderated the discussion. We present here a selection of comments from the symposium participants.

BRUCE MURRAY

The topic this afternoon is the implications of space weapons development on civil space activities. You might ask, "Why is The Planetary Society interested in this?" The answer is that the Society feels that this subject hasn't received much attention because of the focus on the national security issues usually discussed in the current debate on space weapons.

Another question might be, "Why should The Planetary Society sponsor this symposium?" We are a very large, international group of people — over 100,000 members — committed to and united by interest in the exploration of the planets, the search for extraterrestrial intelligence and, in general, the use of space to advance science. We have come to believe very strongly that these objectives should and must be done through peaceful, international cooperation. Thus, we are interested in all developments that might affect, either positively or negatively, the opportunities for peaceful international cooperation in space.

The Planetary Society will not take a position on the issue of space weapons, although individuals among us may have their own views. As we see it, our role is to provide information to help people deal with these policy issues and how space weapons may advance or hinder the exploration of space. How should we go about this? Our approach is to bring together a distinguished panel, each with civilian space experience and a good background in space technology. Our panelists today are: Dr. Philip Morrison, Institute Professor at the Massachusetts Institute of Technology; Dr. Greg Canavan of Los Alamos National Laboratory, substituting for General James Abrahamson, head of the Strategic Defense Initiative office, who was not able to be here today; Academician Roald Sagdeev, Director of the Institute for Cosmic Research of the Soviet Academy of Sciences; Dr. Carl Sagan, Director of the Laboratory for Planetary Studies, David Duncan Professor of Astronomy at Cornell University and President of The Planetary Society (although we emphasize that today Dr. Sagan is speaking for himself and not necessarily for the Society); and Dr. Robert Cooper, Assistant Secretary of Defense and Director of the Defense Advanced Research Projects Agency, and former Director of NASA's Goddard Space Flight Center.

PHILIP MORRISON

There are two major dynamic and growing forces that run as strong threads throughout all our centuries. They are the rise of science and technology, and the rise of the nation-state. The greatest conflict in the world, probably more enduring than that between war and peace, or between the several states, or even between the rich and the poor, is the conflict between the steady and cumulative growth of these two institutions. I don't think that we will long endure as a complicated, world-inhabiting species if we don't, within some proximate future, find some way to moderate the impact of the simultaneous rise of these two forces.

The powers given by science and technology to the state transcend the traditional, characteristic scales and operations of humanity. And of these, the most conspicuous is the matter we are discussing today. I think the clearest problem is that we need to moderate, to temper, to avoid establishing another permanent nation-versus-nation battlefield in space. If we don't do that, we will not be able to exploit that domain in the way promised by enthusiasts for the civil uses of space. We are taking a fateful step when we consider the militarization of space — not only for itself, but also for its grave effects inhibiting the civil use.

GREG CANAVAN for Gen. James Abrahamson

In the last few months the Strategic Defense Initiative has been very much in the spotlight. And it will continue to be very visible. An overview of what we have done and what we will be doing may prove helpful in the thesis that the SDI will be a positive catalyst for the civilian uses of space.

The immediate objective of the SDI program is research into those technologies enabling the development of defensive sys-

tems capable of intercepting and destroying ballistic missiles after they've been launched and preventing their impact. We believe that the technologies under consideration are promising enough that, with continuing effort, a future administration and Congress, if they choose, will have a very real option to design, build and deploy an effective defense against ballistic missiles, a defense that will not threaten people as nuclear ballistic missiles do today.

There will be no way in which the spectrum of benefits for defense, and for direct stimulation of the economy, and for enhanced productivity, can be accurately measured. And of course, there will be no way to accurately assess the sense of hope and optimism that the SDI program will give to each and every American. However, technical achievements alone will not assure the success of the SDI program. We appreciate that the factors that may be most inherent to our success are greater public understanding and acceptance of the dynamic technologies under consideration.

We must continue to strive to make the [SDI] program affordable, and as much as possible, to see that the benefits of our research also accrue to civilian space applications and to the public at large, essentially creating a return on investment for the American taxpayer that provides benefits even beyond enhanced security.

A key milestone would involve outlining and coordinating current applications of past and ongoing research and their potential applications, as well as highlighting the potential economic benefits that they could bring to the nation.

Military investment has been a catalyst to the flexible, adaptive and innovative elements of our industry. The space program has yielded and will continue to yield substantial benefits to the nation and the world. Its influence has been a major factor in keeping many segments of our industry competitive in the world market place.

Relative to the SDI, computer, communication, propulsion and laser technologies have attractive and significant spin-off possibilities. They can serve to solve technological problems in related fields. Clearly they could help the SDI program pay for itself and they could help other defense programs as well.

Costs on other defense and space-related programs could be sharply reduced if we could appropriately harness the synergism that SDI can generate. For instance, we could curtail many one-of-a-kind satellite procurements, lower unit costs, reduce development and production times, and achieve greater interoperability and standardization. With the prospect of applying production-line techniques to satellite manufacturing to drive costs down exponentially, the production of multipurpose satellites, differentiated and customized through use of plug-in modules, long-distance, low-cost transmission of energy by laser beams, and miniature parallel processing computers, can all become practical realities.

Our SDI work on lasers could expand this use into the high power regime. We have the potential of harnessing laser technology to create communication lines of almost unlimited band width. For military applications, laser communication will be difficult to intercept and counter. For commercial applications, line rates and the number of circuits could go up exponentially.

Similarly, our need for advanced operational signal processors, such as those started by the Defense Advanced Research Projects Agency, will help sustain the rate of growth in new semi-conductor materials and technologies. We readily envision the possibility of memory chips storing many millions of bits of information, a vast increase in information storage density over memory chips now coming on to the market. Component size and power requirements will continue to decrease.

Perhaps one of the most universal benefits for science and commerce in space will be the dramatic reduction in the cost of space transportation. Our goal is to reduce the cost of taking large payloads to orbit by a factor of ten or more. This will be a major challenge, but also an incredible benefit for all — if it can be achieved. There can be no question that the Strategic Defense Initiative will yield great benefits for all of us on Earth.

These benefits will include important technology advances that will go far beyond the military objectives of the program. But most important of all, this initiative may well pave the way to a more secure world, one where adversaries no longer threaten each other, perhaps even one where adversaries will remain confident of their security and then be able to move forward to new heights of cooperation in every field for the benefit of mankind.

ROALD SAGDEEV

I would like to list the potential implications of the militarization of outer space. First is the impact of military activity on the technological and scientific objectives in space. Second are the economic implications: A lot of resources would be taken by military development. Third are legal problems: For example, frequency allocation for telecommunication and simple room allocation in geostationary orbit. Of course, most important are the political implications. If we bring together in space the fleets of civilian spacecraft and the superfleets of military spacecraft, then the whole climate will become extremely dangerous. Instead of having enormous space available for everybody, we would be in a situation that might remind you of the Strait of Hormuz.

How could international cooperation ensure that we move into a better future in space? First, if we jointly possessed some objects in space, we would probably feel that space is not the personal property of anybody, not even the private possession of a group of people or a nation. The laws of nature — celestial mechanics, gravity — make it our joint possession.

We have a long history of cooperating in space and I would like to remind you of a few examples. *Apollo* and *Soyuz* joined in flight. Some scientists criticized this project for not being sufficiently scientific, and some people considered it to be simply political. But it was done in a good spirit, and if it had continued, we certainly would have undertaken some interesting and important joint scientific ventures.

We cooperated on and even jointly planned such missions as *Pioneer* Venus and several *Venera* missions. We interpreted the data together. We still cooperate in life sciences and exchange data on human physiology in weightlessness.

Maybe even more important, we now also have a joint program in saving lives: the space system called SARSAT, which stands for Search and Rescue Satellites in your language; in our language it's called COSPAS. You could argue that not many lives were saved with these systems, but I think it is very important because it was purely humanistic cooperation.

The *Vega* spacecraft now on their way to Venus, and then to Halley's Comet, carry an extremely valuable contribution [a cosmic dust counter] from American scientists. And the *Vega* signals are being tracked by [NASA's] Deep Space Network.

I would like to stress that it is, in my view, absolutely incompatible to have large-scale military preparations in space and also have large-scale cooperation. From a psychological and political point of view, this kind of cooperation would always be the focus of the mass media, and the military would try to stay out of the focus. Cooperation would play the role of tranquilizer, and distract public attention from the danger of the militarization of outer space.

Let me add just one last thought. Long ago the sky was a magnificent, ancient dome of the gods. Then with the help of science, it was converted (I would not insist on complete conversion; I would agree to co-existence) into an uncompassionate but infinitely beautiful scene controlled by the laws of nature.

Now we are going to take the next step, converting space into a theater for military operations. This idea that we can contain David on one side of the theater and Goliath on the other is completely wrong. Once this sort of dangerous development goes on, the play would not be contained only in space, unfortunately.

CARL SAGAN

When I was growing up there was a kind of mythos attached to space. It was an arena for exploration, a regime that posed deep questions about life elsewhere, about the uniqueness of what we have here on Earth. It was exhilarating, exciting, forward-looking. Space represented a kind of hope for the future. But for youngsters today — look at television, movies, comic books or the other apparatus of popular culture — space has become an arena for warfare, bloodless, video arcade warfare.

I'm not against the militarization of space. I think "militarization" is a misleading word. We have been militarizing space for decades in the sense that there are military reconnaissance satellites in orbit, and they're worth their weight in gold. They're stabilizing. They prevent mis-evaluations of the moves of the other side, the historic military predisposition to assume the worst about the potential adversary.

So it's not at all that there's no function for the military in space. It's the introduction of *weapons* into space that is the issue before us, and it worries me very much.

Dr. Canavan talked about stimulating the economy as one of the wonders of "Star Wars." I think it's clear that if you wave a trillion dollars at the US aerospace industry, you will get striking results, whether or not the argument for deployment is valid, and whether or not the net result will be a dramatic increase or, as I believe, a dramatic decrease in national security.

We have heard the arguments about spin-offs before. NASA also, on occasion, uses spin-off arguments. The typical argument (they're not all this bad) is something like this: Let us spend $25 billion to put an astronaut on the Moon, and we will throw in a free stickless frying pan and a cardiac pacemaker. A deal sweetener. Now most people know that you can develop stickless frying pans and cardiac pacemakers directly, without going to the Moon, and for considerably less cost. I don't think that the Strategic Defense Initiative ought to be justified on the grounds that there will be wonders for the economy. This is a pernicious argument.

We are at a clear branch point, a time when the same capabilities that can destroy us — the same rocket technology, the same nuclear technology — can also be used to carry us to the planets and the stars. Let's remember that the words written on that plaque in the Sea of Tranquility are, "We came in peace for all mankind." There was a sense then of what NASA is about and I'm very worried that that sense is rapidly eroding.

If you are interested in pumping the economy, there are far better ways to do it. Think of the major cooperative programs which are fully within our technological capability and which could be done at a tiny fraction of the cost of "Star Wars" technology. Think about a joint US/Soviet manned (and womanned) mission to Mars.

Such a mission cannot be justified on its scientific value alone, no more than the *Apollo* missions could. But if a mission to Mars were considered politically desirable — as a token of a serious recommitment by the US and USSR to work together for the benefit of the human species — it could be done for a comparatively modest amount of money. That would be something we would be proud of 1,000 years from now, which I believe is not the case for "Star Wars," if we survive that long.

ROBERT COOPER

As Carl has pointed out, those of us who have grown up in the space era look at space with an emotional eye, and it has an extraordinary allure for us. In the Pentagon, you can hear extremists caught up in this allure say that we should seize the high ground of space to keep the nation secure. On the other hand, in the civil community, you hear people calling for making space a sanctuary from military operations — meaning not only a refuge and an asylum, but also a sacred or holy place.

But when you get down to business, these dramatic appeals are quite unrealistic and not helpful as guiding principles for any of our space endeavors, whether they be scientific activities, space exploration, commerce or military operations.

Let me tell you that, from a military point of view, there is absolutely nothing special or dramatic about space. It is just another environment in which human activities will take place, and one of those activities is bound to be military.

So what are the potential impacts from a hardheaded, military point of view? First of all, there are budgetary constraints. I know there is concern within the scientific community that the funds they are provided by the federal government will be affected by our increased investments in the space technologies inherent in the weapons program known as the Strategic Defense Initiative. But that strategic defense budget of $25 billion over the next five years in no way competes with the NASA budget, or with the budgets of any other agencies.

In fact, the historical record shows that whenever the military budget for space has gone up, so have the budgets in these other organizations. There is a cumulative drawing effect that seems to occur; as the tempo of military activity in space rises, there are corollary effects in other programs.

Now, what about research spin-offs? My view is that the civil community will benefit widely from the step-up of research activities. Let me give you a couple of examples. The Planetary Society should know well that without the *Titan* 3E *Centaur* system, some of our most ambitious projects, including the *Viking* landing on Mars, would not have been possible. Both the *Titan* and the *Centaur* were developments of the Defense Department and those systems would probably not have been available to the science community if Defense had not produced them for other purposes.

The sensors and the optical systems that will fly aboard the Space Telescope — which I believe will be one of the greatest scientific triumphs of man when it goes into orbit — could only have been possible with the developments of the Defense Department.

We believe we have conquered the technology required to project laser beams upward through the atmosphere, correcting for atmospheric turbulence. If we were to turn that technology loose to optical astronomers to produce large optical systems that can correct for atmospheric turbulence, there's no telling how deep into space they might be able to see from the surface of Earth. Maybe the search for extraterrestrial intelligence could be done optically.

Out of this program of strategic defense will come advanced computers that we can put into our satellites, and they will be as powerful as the largest computers that we have on the surface of Earth today. Within a few years those processors will be available to the scientific community.

Now, Carl says, sure we could do that with funding for civil purposes, and certainly we could, but I am pointing out that included in the strategic defense program are technical accomplishments that will become available to the civil, commercial and scientific communities.

The allure of space will remain an emotional issue, both in the civil and military space communities. But actually, the hardheaded issues of the bottom line, the competition for resources, will really determine what happens. Clearly there will be some connection between civil and military space activities, but my view is that the impacts on each other are going to be minimal.

(continued on page 18)

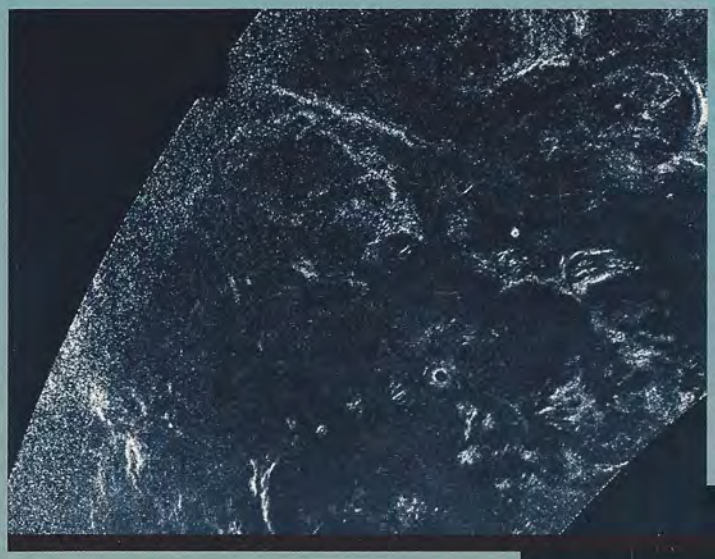
INVESTIGATING VENUS

ARECIBO RADAR MAPS THE PLANET

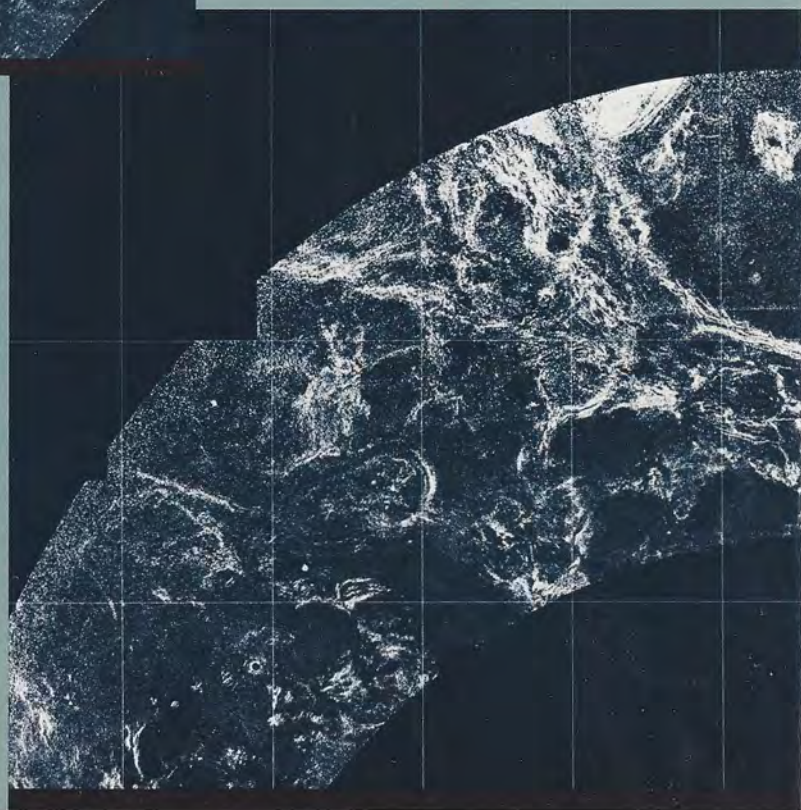
With successful spacecraft missions grabbing the spotlight, Earth-based studies of the planets have not always received the attention they deserve. Modern instruments and techniques, such as radar, have allowed scientists to investigate certain portions of the Moon, Venus and Mars with detail-resolving power approaching that of orbiting spacecraft. These observations are valuable complements to spacecraft investigations of the planets.

The powerful radio transmitter and the 300-meter antenna of the Arecibo Observatory, aided by advanced signal receiving, processing and computing techniques, enable scientists to map parts of Venus' surface directly from Earth. The relative motions of Earth and Venus change the frequency of the radar signal bounced back from Venus, an effect called the Doppler shift. The frequency difference provides us with a measure of the relative velocity of Arecibo and regions on the surface of Venus. Combining this with distance measurements obtained by observing how long the signal takes to make a round trip, scientists are able to create two-dimensional maps of the surface. These maps show local slopes, elevations and topographic features on the surface. In addition to these effects, the amplitude (loudness) of the signal return is affected by the character and roughness of each element on the surface. Rough areas appear as "radar-bright," with higher reflectivity. Smoother areas are "radar-dark."

Here we present a few examples of radar images taken by the Arecibo Observatory in Puerto Rico, operated by Cornell University. These images are the work of Donald B. Campbell, Director of the Observatory, and Ellen R. Stofan and James W. Head of Brown University. Dr. Head wrote the captions for these images.

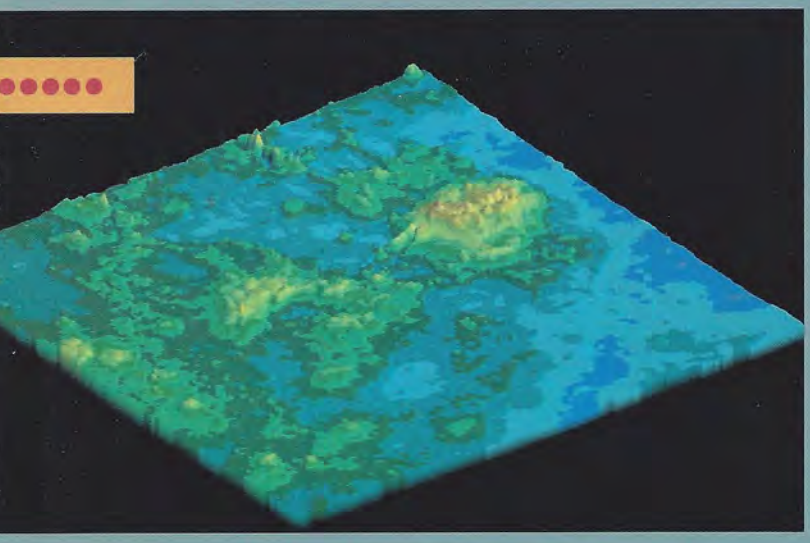


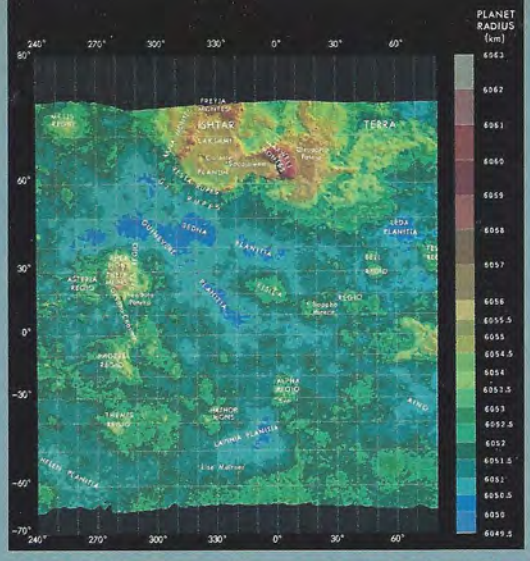
← *Guinevere Planitia* (Latitude 39-60 degrees; longitude 269-301 degrees) The large oval feature (upper right) about 350 kilometers across lies on the plains just north of Beta Regio. The *Venera 15* and *16* missions found many similar features on the plains in Venus' far north, a region not explored by the *Pioneer* Venus mission and not visible to the Arecibo radar. We do not know the origin of such features, but they could be remnants of ancient impacts, structures formed by the deformation of Venus' hot crust, or evidence of movement or convection in the planet's hot interior.



Guinevere Planitia and Southwest Lakshmi Planum → (Latitude 40-70 degrees; longitude 270-330 degrees) This image shows the transition from a highland region (Ishtar Terra), seen in the upper right corner, to the upland rolling plains and lowlands (Guinevere Planitia) in the center to lower left. The highland area is characterized by a relatively flat, radar-dark plateau (Lakshmi Planum) of smooth lava plains, bounded by mountain ranges rising one to three kilometers above the plateau. These mountains appear here as bright parallel bands. We think this banded terrain is the result of compression during the formation of these high, linear mountain belts.

The transition from the highlands to the lowlands several kilometers below is marked by the bright linear bands and swirls stretching from east-southeast to west-northwest across the upper central part of the image. The lowlands (lower left) are primarily dark, smooth plains, probably lava flows, marked by radar-bright rings between 75 and 300 kilometers across. Also seen by the *Venera 15* and *16* radar-mapping missions, these features, called coronas, are of unknown origin. At the extreme lower left are several bright linear features, the northernmost extension of the great rift system of Devana Chasma in Beta Regio.





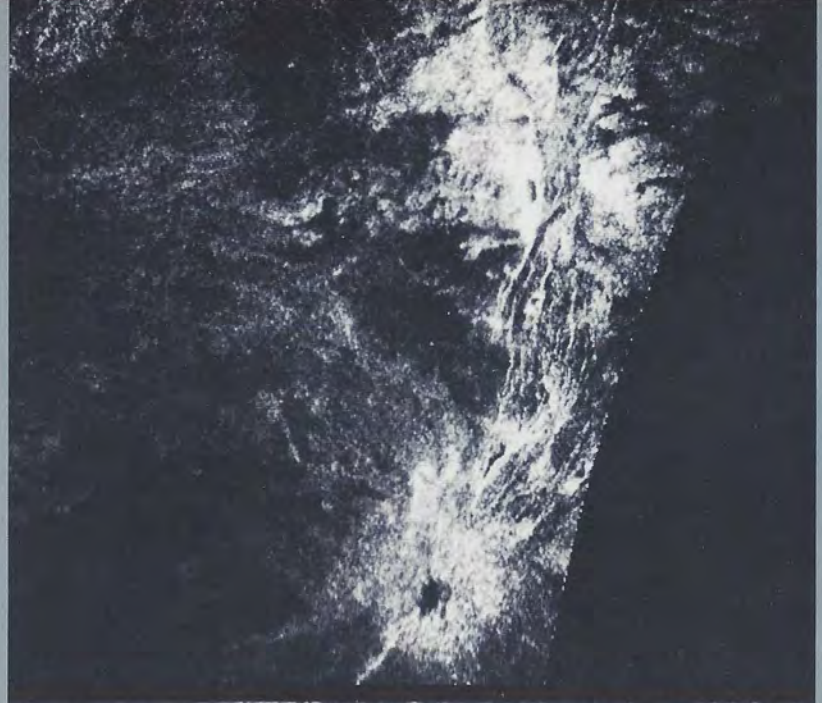
ABOVE: This topographic map, generated from *Pioneer* Venus radar altimetry data, covers the regions imaged by the Arecibo Observatory and displayed on these pages. MAP COURTESY OF HAIG MORGAN, USGS

LEFT: Using *Pioneer* Venus radar altimetry data, researchers at the United States Geological Survey in Flagstaff, Arizona created this perspective view of a portion of Venus. Blue areas are lowlands; yellow areas are highlands. The large yellow region (upper right) is Beta Regio, a site of probably active volcanos. IMAGE: ERIC ELIASON, USGS

Southeast of Lakshmi Planum ⟶
(Latitude 49-60 degrees; longitude 331-351 degrees) Here is, in more detail, the transition from the intense deformation of the edge of Lakshmi Planum and the slope running from the highlands to the lowlands, to the lava plains to the east. On the basis of the embayment relationships, or apparent flooding, and the abrupt termination of the structural features, we think that the volcanic activity is younger than the structural deformation. Many radar-dark lava flows extend for hundreds of kilometers, suggesting that lava emerged from the interior of Venus at very high rates.

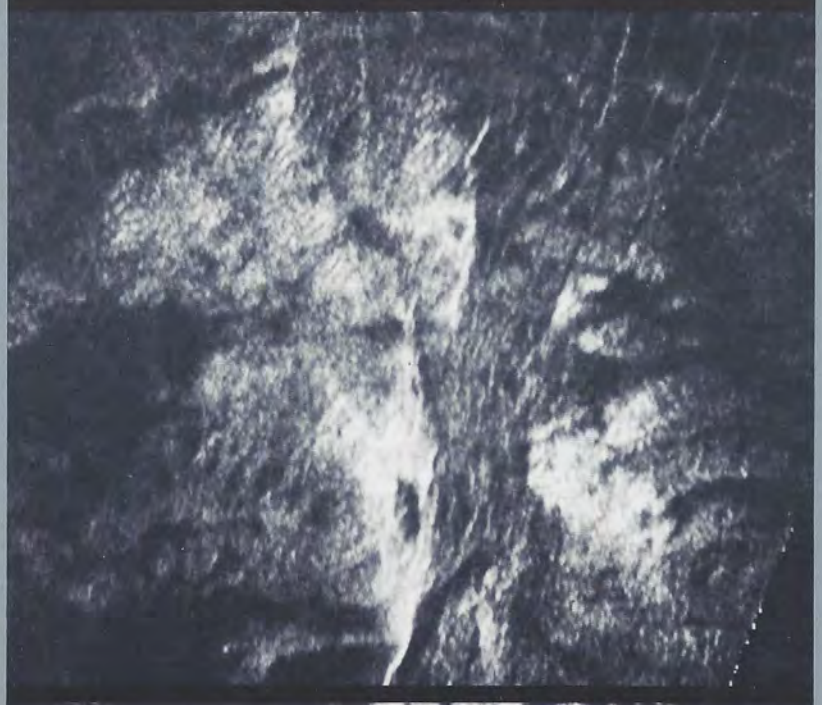
⟵ *Southeast Lakshmi Planum and Sedna Planitia* (Latitude 39-67 degrees; longitude 330-25 degrees) A linear mountain belt of banded terrain lies along the southern border of eastern Lakshmi Planum. The wispy belt marking the transition from highlands to lowlands also lies south of Lakshmi Planum, but in this area the east-southeast trend is interrupted and replaced by bright and dark patterns which appear to be lava flows covering large areas of the Sedna Planitia lowlands. To the southeast are radar-bright arcuate features surrounded by radar-dark plains. These may be the remnants of oval or coronal features that have been partly flooded and covered by radar-dark lava flows.

Several small (less than 100 kilometers in diameter) radar-bright patches can also be seen in this image. Close examination reveals the structure typical of impact craters.

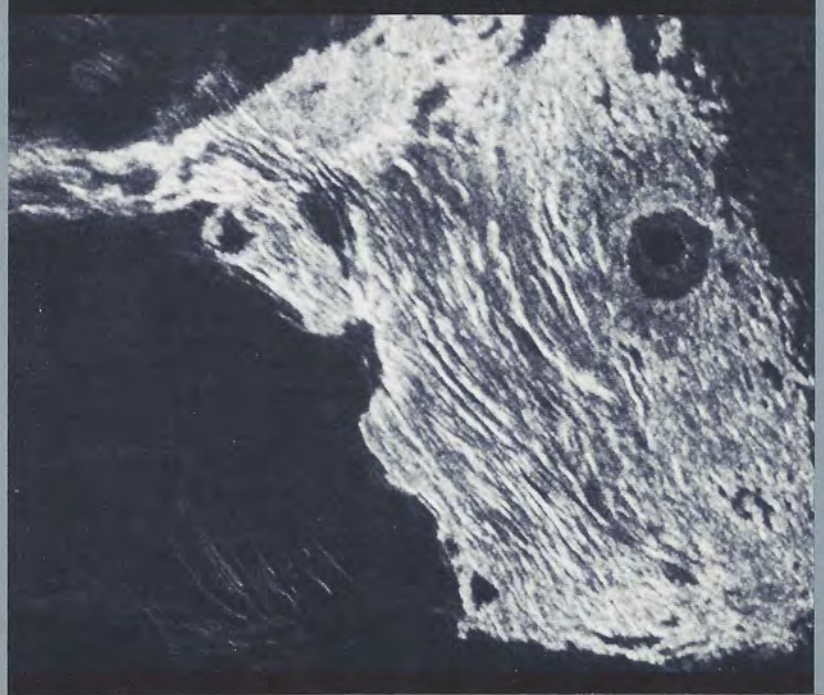


◄— *Beta Regio* (Latitude 18-37.5 degrees; longitude 270-290 degrees) Beta Regio, a region about 2000 by 3000 kilometers in dimension, rises several kilometers above the mean planetary radius (6051 kilometers, used as a reference as is sea level on Earth). We know from *Pioneer* Venus data that Beta Regio has a long trough, Devana Chasma, running along its crest. Several mountain peaks rise one to three kilometers above flanks of the trough. This highly detailed image covers the central and western Beta region and shows that Devana Chasma is marked by a series of bright lines representing faults, which run in a north-south belt (right). The chasma is a giant rift zone similar to the East African rift valley on Earth.

The bright circular area with the dark central spot (lower right) is on Theia Mons, which is probably a shield volcano whose lavas cover many of the faults and fill in the rift valley. The bright spot is about 320 kilometers wide.



◄— *Rhea Mons* (Latitude 35-38; longitude 279-287) Here are details of northern Devana Chasma and Beta Regio. Faults in the rift system, the north-trending, bright linear features, fork and diverge in this area. The bright patch with a dark center on the flanks of the rift system is probably a shield volcano. The lavas that built this volcano may have emerged through cracks in the crust along the fault system.



◄— *Maxwell Montes* (Latitude 61-68; longitude 352-11) This is the highest mountain range on Venus, rising over 11 kilometers above the mean planetary radius. The range is marked by a series of parallel, radar-bright bands 10 to 20 kilometers wide, which have been interpreted as folds and faults from the compressional deformation that formed the mountain. The circular feature on the east side of Maxwell Montes, Cleopatra Patera, resembles craters of both impact and volcanic origin, and is now the subject of intensive study to determine its origin.

World Watch

by Louis D. Friedman

MOSCOW, PARIS and PASADENA — A remarkable experiment in science and international cooperation is being performed by planetary scientists from the United States, France and the Soviet Union.

This June a helium-filled balloon, carrying instruments designed by scientists from all three nations, will be deployed from each of the Soviet *Vega* spacecraft. An international array of about 20 radio observatories, including NASA's Deep Space Network (DSN), will track the balloons as they drift through Venus' thick atmosphere, measuring their positions and velocities, and providing data from which scientists can deduce Venus' winds and air currents.

The scientists' tracking network will use a technique called "very-long-baseline interferometry" (VLBI), in which two very widely spaced antennas on Earth each simultaneously receive radio signals from the balloons and from the spacecraft flying by the planet. By combining these signals, several error sources can be cancelled, allowing scientists to accurately determine the balloons' positions in the opaque atmosphere.

This experiment in international cooperation was arranged principally by Planetary Society advisor, Prof. Jacques Blamont of the Centre National d'Etudes Spatiales (CNES) in Paris. The CNES and the Institute for Cosmic Research in Moscow have a formal cooperation agreement, while the United States will act through a separate arrangement between CNES and NASA's Jet Propulsion Laboratory (JPL) in Pasadena.

The Soviet *Vega* mission, carrying instruments and experiments from a number of countries, including France and Hungary, will place two landers on Venus in addition to the balloon probes. After their deployment, the main spacecraft will fly on to Halley's Comet. They are expected to encounter the comet in March 1986, near its closest approach to the Sun.

Soviet, American and French scientists are enthusiastic about this cooperation. The Planetary Society has been actively encouraging such cooperative ventures; for example, last year in Graz, Austria, we sponsored a meeting among American, Soviet and European space scientists to consider cooperative space ventures. We have also informally discussed US/USSR cooperation with Academician Roald Sagdeev, Director of the Institute for Cosmic Research and advisor to The Planetary Society, and Dr. Valeriy Barsukov, Director of the Vernadsky Institute.

An engineering test model of the *Vega* balloon gondola floats through the hospitable atmosphere of Earth.
Photo: IKI/CNES

Among the opportunities for cooperation are the Soviet mission to Phobos, a moon of Mars, and the US Mars Geoscience/Climatology Observer (MGCO). Both missions are scheduled for launch within the next decade. A joint experiment to track Phobos would be valuable, but the lack of a US/USSR space science cooperation agreement makes it difficult to obtain approval for this experiment in the US.

WASHINGTON — In a related item, a group of Republican and Democratic senators joined Senator Spark Matsunaga (D-HI) in sponsoring a Senate joint resolution calling for cooperation between the US and the USSR in the exploration of Mars. The Phobos and MGCO missions were singled out for early joint work, and both nations' goal of sending humans to Mars was given as a reason to cooperate.

Citing Society President Carl Sagan's advocacy of planetary exploration, Senator William Proxmire (D-WI) spontaneously asked to cosponsor the resolution. Also notable is the cosponsorship of Senators Slade Gordon (R-WA), chairman of the Senate subcommittee in charge of NASA's authorization, and Senator Charles Mathias (R-MD).

WASHINGTON — President Reagan's 1986 budget request included a five percent increase for NASA, but only one new program was requested: the Orbital Maneuvering Vehicle (OMV). This new component of the Space Transportation System (of which the Space Shuttle is the first part) will be designed as a remotely piloted, unmanned, reusable spacecraft to extend the Shuttle's capabilities and carry payloads into higher orbits about Earth.

NASA's requests for new space science programs were not approved. However, NASA Administrator James Beggs noted that the President's budget did include the *Galileo* encounter with the asteroid 29 Amphitrite. The Planetary Society had supported this close flyby of the asteroid while the *Galileo* spacecraft is on its way to Jupiter.

The budget also included a special Shuttle payload known as "Astro," a set of three telescopes to be used to observe Halley's Comet early in 1986.

Planetary scientists are concerned about the budget's lack of research and analysis funds, necessary to restore basic research in planetary science to its 1981 level. At a Washington meeting of the Solar System Exploration Management Council, they expressed their concerns and emphasized the importance of the Comet Rendezvous and Asteroid Flyby (CRAF) mission. To meet its 1991 launch date, the mission must receive funding in the 1987 budget, which the President will present next year.

Congress will probably not complete action on the President's proposed 1986 budget before late summer. Among the various proposals they are considering are an overall budget freeze, which would affect much more than NASA, and adjustments to the space programs of both NASA and the Department of Defense.

Current information on the budget deliberations will be provided on the Society's information lines: (818) 793-4328 from east of the Mississippi, (818) 793-4294 from west of the Mississippi.

Louis Friedman is Executive Director of The Planetary Society.

News & Reviews

by Clark R. Chapman

Science writing is big business these days. That is a welcome fact, given the impact of science and technology on modern life and the arcane nature of the subject. Whether articles are written by writers who have learned some science or by scientists who have learned how to write, our culture desperately needs good communication and understanding between the specialist and the layperson. This month I thought I would survey a wider variety of magazine articles than the usual three or four *creme de la creme* that I comment on for each issue of *The Planetary Report*. Unfortunately, they are not all up to snuff.

Missing the Mark

Most disappointing to me were two articles about the Moon. Perhaps it is not surprising that they appeared in magazines that normally don't "make it" in my column. Exciting things have been happening lately in understanding how our planet came to have its Moon. The catastrophist notion that a Mars-sized planetesimal collided with Earth early on, "splashing" out the material that subsequently coalesced into the Moon, received a boost at a conference on lunar origin held last year in Hawaii.

In Shannon Brownlee's article in the March issue of *Discover*, the major contending theories are juxtaposed, with accompanying unrealistic artist's renditions. To Brownlee, the Hawaii meeting was something of a competitive sports match, an admissible metaphor if only a bit of the scientific reasoning for or against the contenders could have been explained – error-free – to *Discover*'s readers.

Typical of the sloppy reporting, Brownlee describes the originators of the "Big Whack" theory (*Discover*'s corny term for what scientists call the "Collisional Ejection" model) as a geochemist and a painter. Bill Hartmann, a distinguished planetary scientist and talented painter, would never call himself a geochemist and his colleague, Donald R. Davis, doesn't paint. The discussion of the science is equally unreliable.

Even worse, however, is John Holmes's "Moon Mullings" in the March 19th issue of American Airlines' flight magazine *AmericanWay*. He misses the whole point of post-*Apollo* scientific research about the Moon.

The Comet Deluge

The February issue of *Physics Today* has a nice review article about asteroids written by Tom Gehrels. If not as well written as some of the articles under review here, it is at least scientifically reliable. Its fault is in not living up to the second half of its title, "Asteroids and Comets." But do not despair that Gehrels forgot to write about comets, for we are being deluged with pre-Halley's Comet articles these days. One satisfactory example is Debra Elmegreen's introduction to comets in the March *Astronomy*.

Mercury, in its January/February issue, chose for its treatment to reprint excerpts from a recently published book on comets. In one of the two comet articles in the March *Science 85*, John Tierney describes the artificial comet created (for a few minutes) over the Pacific Ocean last Christmas by satellite-release of a cloud of barium. We read of the less-than-roaring success of the experiment from the perspectives of both the German scientist who had planned it for the past decade and a fifth grader, who had hoped to snap a photo of the would-be aerial display for her science fair project.

Comets are also fun for amateur astronomers to observe with their telescopes. Buried in the midst of a little-known (except by amateurs) magazine called *The Strolling Astronomer* (also called "The Journal of the Association of Lunar and Planetary Observers") is a jewel of science writing: a brief introduction to Halley's Comet by the ALPO Comets Recorder, David Levy (Levy's portrait graces the front cover of this February issue of the *Stroller*, as the co-discoverer of one of the winter's brightest comets). Elsewhere in the same issue are reports of amateur observations of sunspots and of the planet Jupiter, continuing a centuries-long tradition of amateur synoptic coverage of these phenomena. (See the fascinating re-analysis of Galileo's pioneering eyeball data about Jupiter by G. D. Parker in *Science*, February 8th issue.)

The programs of persevering amateurs should be emulated by national funding agencies which turn on, and then off, the professional equivalents — solar observatories and telescopic planetary photography patrols. A new and particularly fruitful area for amateur research is asteroids (see Jay Gunter's article in the aforementioned issue of *Mercury*).

Specialists vs. the Mass Media

Although their writings often reach a small audience, specialists and enthusiasts usually seem to do a better job of presenting their interests than do mass-media publications. *Omni* recently devoted a special edition to the planet Mars, but more substance about plans for future Mars exploration can be found in the September 1984 issue of the National Space Institute's *Space World*. The best articles, I usually find, are those written by top scientists in a few moderately large circulation magazines that are proud of the quality of their editorial content. Two recent examples are David Morrison's "The Enigma Called Io" in the March *Sky & Telescope* and Ronald Prinn's "The Volcanoes and Clouds of Venus" in the March *Scientific American*.

Much has been written about planetary catastrophes. Gehrels' asteroid article confidently ascribes some Cretaceous-Tertiary extinctions to an asteroid or comet impact, possibly due to a comet shower induced by "Nemesis" (although that hypothetical object's spell in the spotlight now seems to be past; see Ray Grasshoff's article in the March *Astronomy*). Some scientists still doubt an impact had anything at all to do with extinctions, as discussed in the lead story in the March 8th *Science*.

Nuclear winter is a catastrophist's view of the future, now even endorsed as possible by the Department of Defense, which somehow has managed to use the dreadful scenario to justify further weapons development (*Science*, March 15). There is an even more certain evolutionary catastrophe being wrought by humankind. As described by Norman Myers (*Natural History*, February 1985), extinctions caused by slash-and-burn destruction of tropical forests may exceed anything recorded in the geological record of our planet.

Clark R. Chapman contemplates the solar system from Tucson, Arizona.

SOCIETY-NOTES

SOLAR SYSTEM ENVIRONMENT

The Planetary Society and the journal *Environmental Ethics* will cosponsor a conference on "Environmental Ethics and the Solar System" at the Georgia Center of the University of Georgia, June 5-8, 1985. The program, funded by a National Science Foundation grant, will feature issues related to the exploration and exploitation of the solar system, including legal, social, ethical, aesthetic, environmental, scientific, technical, theological and medical aspects.

Speakers will include science fiction writer Philip Jose Farmer, artist Lamar Dodd, former Secretary of State Dean Rusk and theologian John B. Cobb, Jr. Several philosophers will participate as well, along with technical experts from NASA, the National Oceanic and Atmospheric Administration (NOAA), Congress and the private sector.

If you want to attend, contact Eugene C. Hargrove, *Environmental Ethics*, Department of Philosophy, University of Georgia, Athens, GA 30602. You may also call (404) 542-6875 for information. Discount air fares are available.

THE VIEW FROM SPACE

"Dinosaurs, Greenhouses and Ice Ages — The View from Space," a public session sponsored by The Planetary Society, will be held at the California Institute of Technology Beckman Auditorium in Pasadena on June 8, 1985, from 1-4 pm. Speakers will be: Dr. Eugene Shoemaker, leading expert on asteroids, comets and cratering (see the interview in the January/February 1985 *Planetary Report*); Dr. James Pollack, one of the most respected atmospheric scientists and co-author of the Nuclear Winter hypothesis; and Dr. Harold Masursky, a leader in American and international space exploration. Dr. Bruce Murray, vice president of the Society, will moderate the discussion. Tickets are available through the Caltech ticket office or Ticketron: $5 for the general public, and $3 for members of The Planetary Society. (This session will conclude a scientific conference, "Terrestrial Planets: Comparative Planetology," that the Society is cosponsoring June 5-7, 1985, at Caltech.)

GRAZ REPORT

The Planetary Society internal memorandum, "US/USSR Cooperation in Exploring the Solar System," known informally as the Graz Report, has now been released and circulated to leading officials and scientists in the US and Soviet space programs. Several administration officials commented that the non-governmental, informal meeting hosted by the Society in Graz, Austria, served a valuable purpose in initiating new consideration of opportunities for space cooperation. The meeting was held prior to the President's signing of the Congressional Resolution sponsored by Senator Spark Matsunaga (D-HI), urging renewal of a US/USSR space cooperation agreement.

FLAGSTAFF ASTRONOMY MEETING

Comets and asteroids will be the focus for the Astronomical Society of the Pacific's 97th annual meeting at Northern Arizona University in Flagstaff, June 22-28, 1985. There will be a day of non-technical lectures on new developments in astronomy, a workshop on teaching astronomy in high school and college, a lecture on the return of Halley's Comet, and a scientific symposium on comets and asteroids. Special tours are planned to local places of interest, including Meteor Crater, the Lowell and US Naval Observatories, a Native American archaeo-astronomy site, and the Grand Canyon. For further information, write: Summer Meeting, A.S.P., 1290 24th Avenue, San Francisco, CA 94122.

HUMANS ON MARS?

"Steps to Mars" will be the title of a conference to be sponsored by The Planetary Society in Washington, DC, on July 16 and 17, 1985. While commemorating the tenth anniversary of the *Apollo-Soyuz* US/Soviet space mission, it will also point the way toward possible future cooperative ventures. The Society hopes to encourage consideration of a policy that will allow official planning for human exploration of our neighboring world.

Cosponsors with the Society are the American Institute of Aeronautics and Astronautics and the National Air and Space Museum of the Smithsonian Institution.

The program on July 16, at the National Academy of Sciences auditorium, will include:

— An American Institute of Aeronautics and Astronautics technical session led by Dr. James French of JPL about biomedical and physiological aspects of a human flight to Mars, mission design and engineering, science, and robotic missions.

— A Planetary Society panel led by Society Vice President Bruce Murray entitled "Humans to Mars — Why?" Panelists will include Society President Carl Sagan, Society Advisors Sally Ride and Harrison Schmitt, NASA Administrator James Beggs, and ESA Director Roger Bonnet.

— A ceremony and reception commemorating the tenth anniversary of the *Apollo-Soyuz* mission.

The July 17 program will be a National Air and Space Museum conference entitled "International Utilization and Exploration of Space."

To get tickets and a program for this event, write: The Planetary Society, Mars Conference, 110 S. Euclid Avenue, Pasadena, CA 91101, or call (818) 793-5100.

ASTEROID CONTEST

Out beyond Earth, an asteroid is waiting for Planetary Society members to give it a name. Jet Propulsion Laboratory planetary scientist Eleanor Helin, director of The Planetary Society and World Space Foundation Asteroid Project, discovered the asteroid. The Minor Planet Center of the Smithsonian Astrophysical Observatory has officially numbered the asteroid (3129)1979MK2.

Helin is allowing Planetary Society members to give the asteroid a more appealing name, in appreciation for our generous support to the asteroid discovery project. (In the past three years, many discoveries of near-Earth asteroids were made through this NASA program, augmented by The Planetary Society.)

Use your imagination — send us an original idea for the name of this celestial object, and your idea may have an official, permanent place in the heavens. Prize for the winning entry will be a commissioned original asteroid painting. Send your entry printed or typed on a 3"x5" postcard — one per card. Deadline is July 15, 1985. The winner will be announced in *The Planetary Report*.

The asteroid (3129) was discovered on June 25, 1979 from Australia by Helin and S.J. Bus. It orbits the Sun once every 4.4 years, traveling in the Main Belt of asteroids that lies between Mars and Jupiter.

YOU TELL US

THE PLANETARY SOCIETY MEMBERS' SURVEY

Hopeful visions of humanity's possible future in space were revealed by the thoughtful and imaginative answers The Planetary Society received from its members in response to our members' survey made in 1984.

The ideas and suggestions figuratively spanned the cosmos, ranging from automated missions to Mercury and voyages to Pluto to searching for planets around other stars and listening for murmurs of alien intelligence in the sea of radio noise that washes constantly through space.

> *"I would like my children to have a future in space, studying and exploring the solar system."*

It made exciting reading and was reassuring because it demonstrated vividly that the lure of space is still compelling and that, in the minds of our members at least, the possibilities within reach of available or slightly modified technology hold the promise of marvels.

But while the ideas and opinions expressed were as divergent and colorful as the planets themselves, there was a clear sense of direction implied as well, and that was up and outward bound.

The survey of Planetary Society members sought to find out something about who you are, what you think about us, and what you think about some key questions facing the space program, including the efforts of the United States, the Soviet Union, Europe and Japan. We received about 3,000 completed surveys (2.5 percent of our membership), which is a large response compared to typical surveys but, of course, represents only the most active part of our membership.

Drawing conclusions from the survey responses is tricky and may depend on the way questions were asked. And the opinions of those motivated to respond are not necessarily those of the whole membership.

Learning About Ourselves

Nonetheless, the survey was helpful in learning a great deal about ourselves. We appreciate the many responses (which filled 10 boxes at various times around the office). We also wish to salute the efforts of the many volunteers who helped tally the answer sheets.

> *"A manned Mars landing would be a triumph for humankind, as well as an enticement for more manned exploration."*

Their task was not without reward, as they enjoyed seeing firsthand the thousands of additional comments ranging from flippancy (calls for more parties) to thoughtful essays both for and against international cooperation in space. These were circulated to the staff and officers who conduct and direct the Society's operations.

The survey tells many interesting things about the responding part of the Society's membership. It is predominantly male (85 percent, with 15 percent female); a majority of those responding (64 percent) are between 26 and 49 years of age, with 6 percent each in the over 65 or under 18 category. The annual income range is wide-spread: 23 percent earn less than $20,000 per family, while another 23 percent fall in the $20,000 to $30,000 range, 19 percent say their family income falls between $30,000 and $40,000. Fully 13 percent say they fall in the $40,000 to $50,000 bracket and another 18 percent say they earn more than $50,000.

A Broad Spectrum

Politically, our responding members again cross a broad spectrum, with 25 percent describing themselves as conservative, 21 percent as liberal and the remainder as moderate. Two-thirds do not belong to any other space interest group and three-fourths do not routinely attend public lectures about space or science.

On policy issues, the membership was split on the subject of the space station, 48 percent saying to build it now, and 52 percent saying to be cautious before committing to a station. (The Planetary Society is not taking a stand for or against a proposed space station. We will continue to examine how a station could support exploration, science and technology and will keep members informed.)

> *"We should strive for a manned lunar station to enable further exploration from an existing springboard to space."*

A plurality of those responding, 47 percent, favor keeping weapons out of space, with 11 percent agreeing they should be kept out unless another nation puts them there first. Offensive and defensive space weapons are favored by 17 percent, while 25 percent favor defensive weapons only. (The Society will not take a position on this subject, but will encourage discussion on what effect such weapons might have on space exploration. See pages 7-9).

International cooperation in space exploration has become a key initiative of the Society and 58 percent support it, compared to 20 percent who urge competition. While 60 percent say the US should work with its allies, a full 67 percent say it should also work with the USSR. Only 10 percent say the US should go it alone.

Regarding targets for exploration, Mars is the overwhelming choice for more attention. The Moon was in second place. And, 53 percent say we need more human space flight, while 11 percent say we could do more exploration with robot craft. The current level of human exploration is about right for 36 percent of our members.

It is encouraging that the support of space exploration found in The Planetary Society's poll does not stand alone. (Of course, Planetary Society members had already shown their support — simply by joining the Society.) Several other, more scientific polls all show a quickening of the US pulse with regards to space exploration.

This does not mean that the space program enjoys carte blanche backing, however. A majority of the public still holds that we're spending about the right amount on space or should even increase spending, but a significant 45 percent hold that too much money is being spent on the space program. Some polls even show a majority backing a "do less" position.

Jon D. Miller, the director of the Public Opinion Laboratory at Northern Illinois University in DeKalb, said that over the last decade, the percentage of Americans who think the government is spending too much on the space program has declined, with a majority now saying that spending is about right or too low. A substantial number, he said, have reservations about spending money on space and similar programs while important domestic needs go unmet.

Miller concludes that a solid core of 17 million Americans are attentive and back space exploration. About 34 million Americans, he said, have a high level of interest in space, but do not feel they have an adequate level of understanding. Almost 50 million Americans have a high interest in science and technology, but not in the space program.

This, Miller feels, is a very viable and possibly expanding base of public support for space that can be greatly enhanced with improved information programs. □

SOCIETY QUESTIONNAIRE RESULTS

SPACE STATION	May interfere with science **11**
	Go slow **41**
	Build it now **48**
INTERNATIONAL COOPERATION	Most productive **58**
	Competition is better **20**
JOINT US-USSR SPACE STATION *	Never happen **14**
	Probably not, but try **36**
	Would really ease tensions **47**
	Pooling knowledge is best **51**
US-USSR COOPERATION *	US Cooperate only with allies **60**
	US Cooperate also with USSR **67**
	US Cooperate also with Third World nations **46**
	US Go it alone **10**
WEAPONS IN SPACE	No **47**
	Only if another nation introduces **11**
	For defense only **26**
	Yes **17**
MANNED vs UNMANNED EXPLORATION	More humans in space **53**
	Fewer humans in space **11**
	About right **36**
SOCIETY POLITICAL ACTIVITY	Much more active **27**
	A bit more active **26**
	Remain the same **35**
	Less active **2**
	No activity **9**
THE PLANETARY REPORT	Fascinating **41**
	Good **43**
	OK **17**
	Inadequate **2**
POLITICS	Conservative **25**
	Liberal **21**
	Other **53**
HOUSEHOLD INCOME	$0 — $10,000 **7**
	$10,000 — $15,000 **7**
	$15,000 — $20,000 **9**
	$20,000 — $30,000 **23**
	$30,000 — $40,000 **19**
	$40,000 — $50,000 **13**
	Over $50,000 **18**
EDUCATION	Less than high school **5**
	High school graduate **9**
	Some college **29**
	College graduate **35**
	Masters degree **16**
	Ph.D or M.D. **8**
MEMBER OF OTHER SCIENCE GROUP	Yes **36**
	No **64**
RESIDENCE	City **43**
	Suburb **40**
	Rural **16**
SEX	Female **15**
	Male **85**

* More than one answer could be checked.

Mission to Mars

Considering these results, the Society's Board of Directors is examining an international manned mission to Mars as a possible goal for space exploration. The Society will hold a symposium on this subject in Washington, DC on July 19-20. (For more details, call the Society's information lines, 818/793-4328 from east of the Mississippi and 818/793-4294 from west of the Mississippi.)

An overwhelming majority of our responding members enjoy *The Planetary Report*; 82 percent say it is fascinating or good, while 19 percent thought it was only adequate at best. More interviews and essays were requested by 46 percent.

A bare majority (53 percent) would like us to be more politically active, although 35 percent say we should stay about the same and 11 percent feel we should be less active. A quarter of those responding checked the "much more active" category, while 10 percent want us to stay entirely out of politics.

A majority want more Society-sponsored events, particularly lectures and slide shows. The Board of Directors has accepted these recommendations, and we are starting a lecture program in cooperation with the American Astronomical Society's Division of Planetary Sciences.

So there you have it, an idea of who makes up the Society and what they would like us to do. The Planetary Society is a diverse collection of people linked by a common thread: curiosity about what's beyond Earth's thin biosphere and what our future could be among the planets.

We thank Julian Loewe for his help in formulating the survey and analyzing the results.

(continued from page 9)

COMMENTS, QUESTIONS AND ANSWERS

After the symposium participants finished their prepared statements, Dr. Murray opened the discussion up for questions and further comments.

Bruce Murray: I am representing the audience with a question to Phil Morrison: "Isn't trying to keep weapons out of space in the 21st century like trying to keep weapons out of the American continent in the 16th century? Sooner or later, must it not happen?"

Philip Morrison: That is a very good question. I cannot say what will happen, and perhaps it is inevitable. Perhaps the forces that drive us are beyond our control. But I want you to think of biology, meteorology and unknown technologies latent in the sciences of today, which 30 years from now could form the basis of severe environmental or human change. Sooner or later we have to come to grips with the fact that we cannot continue always to take the short-run gain over an adversary by introducing new technology, because the scales of new technologies are not limited by the scales of space and time which human beings manage.

There are at least two examples of how to proceed. One of them is well-known, not terribly important, but symbolically very beautiful: Antarctica and the remarkable agreement of the states not to militarize it, and indeed, not to exploit its economic resources. It has worked very well. Now I know there are a thousand practical reasons, which I am sure Bob will be willing to explain to us, why that is not a good example. It is only a symbolic example. But we can begin with such symbolic examples.

Roald Sagdeev: I think I have said enough, but I would like to make one statement. The logic of exponential proliferation which we see now in military space expenditures is a most frightening thing. I think we should look at these problems with a different attitude. We are reaching a threshold, not only in expenditures but in risk. Maybe the only way to change our logic, our psychology, in dealing with these issues is to consider that we are now under the threat of the death penalty — all of us. We are in prison together.

Carl Sagan: I would like to comment on what Bob said earlier. Yes, it is true that the *Titan* 3E *Centaur* is a military system, used occasionally for some more benign purposes, but it does not follow that military hardware for space exploration is inevitable or that it is the only possibility. I point out that the largest launch vehicle the US has ever mustered was the *Saturn V* rocket used to launch *Apollo*. It was not a military booster.

There is a striking implication of Bob's comment. There are still *Titan* boosters, still deployed, each with a nine-megaton warhead on it. That same booster sent *Vikings* to Mars and *Voyagers* to the outer solar system. In January 1986, *Voyager 2* will pass by Uranus, all because of that same rocket. The moral symbolism of our uses of technology is, it seems to me, nicely drawn. Robert Browning said, "Things learned on Earth we shall practice in heaven." The question is: Which things?

Robert Cooper: The answer to Carl's question obviously is: all things. All things learned on Earth will be practiced in heaven. That was my point. It is inevitable that military activities or operations will be conducted in space, because they are human activities. All human activities will be conducted in space.

Bruce Murray: I think the discussion has focused on the central issue: Is the future a linear extrapolation of the past, which according to Philip Morrison's view, is a very uncertain future indeed? But there is a sense that we can, therefore we must, try to change that future. Space is viewed as the next frontier for that change. We'll be seeing a lot of political activity on this subject in the coming year. But I think our view should be much longer. We should be looking toward a future in which humans will go to Mars and do many other exciting things. That will be the hallmark of our actions in space. Thank you. □

I.S. SHKLOVSKII

(continued from page 3)

book *Stars* "was being published in America, a country that has made so distinguished a contribution to the growth of modern astronomy." The political views of this humane man were sometimes critical of both the United States and the Soviet Union. It took considerable courage to make his opinions known. He was repeatedly celebrated in the United States as one of only a handful of honorary members of the American Astronomical Society, as a recipient of the Bruce Gold Medal of the Astronomical Society of the Pacific, and as a foreign member of the National Academy of Sciences.

Shklovskii played a major role in raising the radio search for extraterrestrial intelligence to a level of scientific respectability in the Soviet Union, and in popularizing the whole of modern astronomy in that nation and elsewhere. In the 1960s and 1970s there was a series of false alarms in which strange signals were received from space by radio astronomers in the Soviet Union. Following one such detection there was even a news conference in which the slow periodic variation in brightness of a radio source called CTA-102 was attributed to a signal from a very advanced, probably extragalactic, civilization. But all of these cases turned out to have more natural explanations, CTA-102 being one of the earliest quasars detected.

As time passed, and no sign of extraterrestrial intelligence emerged, Shklovskii became discouraged, and eventually considered seriously the possibility that there is no extraterrestrial intelligence, that in a galaxy of hundreds of billions of stars and a universe with billions of galaxies, we are alone. This was the subject of considerable debate. We argued the matter every time we met. Have we acquired extraterrestrial signals and not recognized them? Are they being sent in some way that we are too backward to detect? Might the extraterrestrials choose not to let their presence be known? Might they all have destroyed themselves — perhaps by nuclear war — before achieving the capability for interstellar communication? But he did not consider his recent views definitive, and willingly signed the international petition urging a concerted global search for extraterrestrial intelligence (see the March/April 1983 *Planetary Report*).

The last time I saw him was in Graz, Austria in August 1984, just before a meeting The Planetary Society had organized in which Soviet and American scientists explored the means for future cooperation in the exploration of the solar system. I remember that he argued that there were evolutionary dead ends, that sometimes species are trapped by their history. He pointed to the saber tooth tiger whose enormous curving tusks were an impediment, not an advantage, in capturing the prey that might run to it.

I.S. Shklovskii made fundamental contributions to the search for extraterrestrial intelligence, and to much of modern astrophysics. There are too few brave and brilliant scientists with a broad planetary perspective. We are all diminished by his death.

Carl Sagan is Professor of Astronomy and Space Science at Cornell University. The 1966 book, Intelligent Life in the Universe, *that he wrote with I.S. Shklovskii is, according to a recent issue of* Time, *"still considered the basic treatise on the prospects for life beyond Earth."*

The Solar System in Pictures and Books

ORDER NUMBER	Books		PRICE (IN US DOLLARS)
001	**Voyage to Jupiter** by David Morrison and Jane Samz. 199 pages.		$11.00
002	**Journey to the Planets** by Patricia Lauber. 87 pages.		$11.50
003	**The Case for Mars** edited by Penelope J. Boston. 314 pages.		$18.00
004	**Out of the Cradle: Exploring the Frontiers Beyond Earth** by William K. Hartmann, Ron Miller and Pamela Lee. 190 pages.	Soft cover	$11.00
008	**The Surface of Mars** by Michael Carr. 232 pages.		$15.00
009	**Voyages to Saturn** by David Morrison. 227 pages.		$14.00
010	**The New Solar System** edited by J. Kelly Beatty, Brian O'Leary, and Andrew Chaikin.	2nd edition	$12.50
012	**The Moon** by Patrick Moore. 96 pages.		$12.00
015	**The Grand Tour: A Traveler's Guide to the Solar System** by Ron Miller and William K. Hartmann. 192 pages.		$ 9.00
016	**Planets of Rock and Ice** by Clark R. Chapman. 222 pages.		$12.50
018h	**The Planets** edited by Bruce Murray. 129 pages.	Hard cover	$15.00
019s		Soft cover	$ 9.50
020	**Murmurs of Earth** by Carl Sagan, Frank Drake, Ann Druyan, Timothy Ferris, Jon Lomberg, Linda Salzman Sagan. 273 pages.		$ 7.00
021	**A Meeting with the Universe** edited by Bevan M. French and Stephen P. Maran. 221 pages.		$15.00
022	**Out of the Darkness** by Clyde W. Tombaugh and Patrick Moore. 221 pages.		$13.00
024	**Distant Encounters** by Mark Washburn. 272 pages.		$11.50
025	**Earth Watch** by Charles Sheffield. 160 pages.		$20.00
026	**Pioneer Venus** by Richard O. Fimmel, Lawrence Colin and Eric Burgess. 253 pages.		$12.50
029	**Atlas of the Solar Systen** by Patrick Moore and Gary Hunt. 464 pages.		$30.00
030	**Worlds Beyond: The Art of Chesley Bonestell** by Ron Miller and Frederick C. Durant III. 133 pages.		$13.00
034	**Imaging Saturn** by Henry S. F. Cooper, Jr. 210 pages.		$13.00
045	**The Comet Book** by Robert Chapman and John Brandt. 168 pages.		$14.00
054	**Voyager: The Story of a Space Mission** by Margaret Poynter and Arthur L. Lane. 152 pages.		$ 8.50
055	**Cosmic Quest: Searching for Intelligent Life Among the Stars** by Margaret Poynter and Michael J. Klein. 124 pages.		$ 9.00

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

ORDER NUMBER	Other Items		PRICE (IN US DOLLARS)
041	**Voyager 2's Future Missions** – Don Davis paintings (set of 2 color reproduction prints)		$ 2.00
042	**Apollo** photograph of Earth – full disk (16" x 20" Laser Print)		$ 8.00
043	**Earthprint** photograph of North America (8" x 10" Laser Print)		$ 4.00
036	**Voyager 1 at Saturn** (Five 23" x 35" posters)		$16.00
037	**Planetfest '81** – Saturn and the F-ring (Two 23"x35" posters)		$ 5.00
044	**You Are Here** (23" x 29" poster)		$ 5.00
046	**Other Worlds** (23" x 35" poster)		$10.00
048	**Voyager 1 Saturn Encounter** (40 slides with sound cassette)		$15.00
049	**Voyager 2 Saturn Encounter** (40 slides with sound cassette)		$15.00
050	**Viking 1 & 2 at Mars** (40 slides with sound cassette)		$15.00
051	**Voyager 1 & 2 at Jupiter** (40 slides with sound cassette)		$15.00
052	**The Solar System Close-Up, Part One** (50 slides with booklet)		$36.00
053	**The Solar System Close-Up, Part Two** (50 slides with booklet)		$36.00
056	**Comets and Comet Halley** (30 slides with booklet)		$24.00
057	**Earthrise** photograph of Earth from the Moon (16" x 20" Laser Print)		$ 8.00
058	**Human in Space** photograph of astronaut in space (16" x 20" Laser Print)		$ 8.00
074	VHS **Universe** (30 min. videotape)		$35.00
084	BETA		
075	VHS **Space: The 25th Year...and Beyond** (51 min. videotape)		$35.00
085	BETA		
076	VHS **The Voyager Missions to Jupiter and Saturn** (28 min. videotape)		$35.00
086	BETA		
077	VHS **Mars, the Red Planet** (30 min. videotape)		$35.00
087	BETA		
088	**Space Shuttle Mission Reports:** STS 5, 6, & 7 (CAV Laser Videodisc)		$36.00
089	**Apollo 17 Mission to Taurus Littrow** (CAV Laser Videodisc)		$36.00
066	**Calendar for 1985**		$ 7.00
078	**Men's T-Shirt** – white with blue logo. S M L XL		$ 9.00
079	**Women's T-Shirt** – navy with white logo. S M L XL (sizes run small)		$ 9.00
080	**Buttons** – blue with logo (2 for $2.50)		$ 1.50
081	**Planetary Report Binders** – blue with gold lettering. (2 for $16.00)		$ 9.00
065	**Back issues** of the PLANETARY REPORT. Each volume contains six issues (Vol I, No. 5 &6; Vol II, No. 1, 5, & 6; and Vol III, No. 1 & 2 have been sold out.) Specify the issues you are ordering by volume and number.	each	$ 2.00

IF YOU NEED MORE ROOM, JUST ATTACH ANOTHER SHEET OF PAPER

NAME

ADDRESS

CITY, STATE, ZIP

COUNTRY

☐ CHECK OR MONEY ORDER ENCLOSED FOR $_____ (Sorry, no C.O.D's)

☐ VISA ☐ MC ☐ AM/EXP EXPIRATION DATE / / / /

COMPLETE ACCOUNT NUMBER _____

SIGNATURE _____

MAIL ORDER AND PAYMENT TO:

THE PLANETARY SOCIETY
110 S. Euclid Ave., Pasadena, CA 91101

ITEM NUMBER	QUAN.	DESCRIPTION	PRICE EACH	PRICE TOTAL

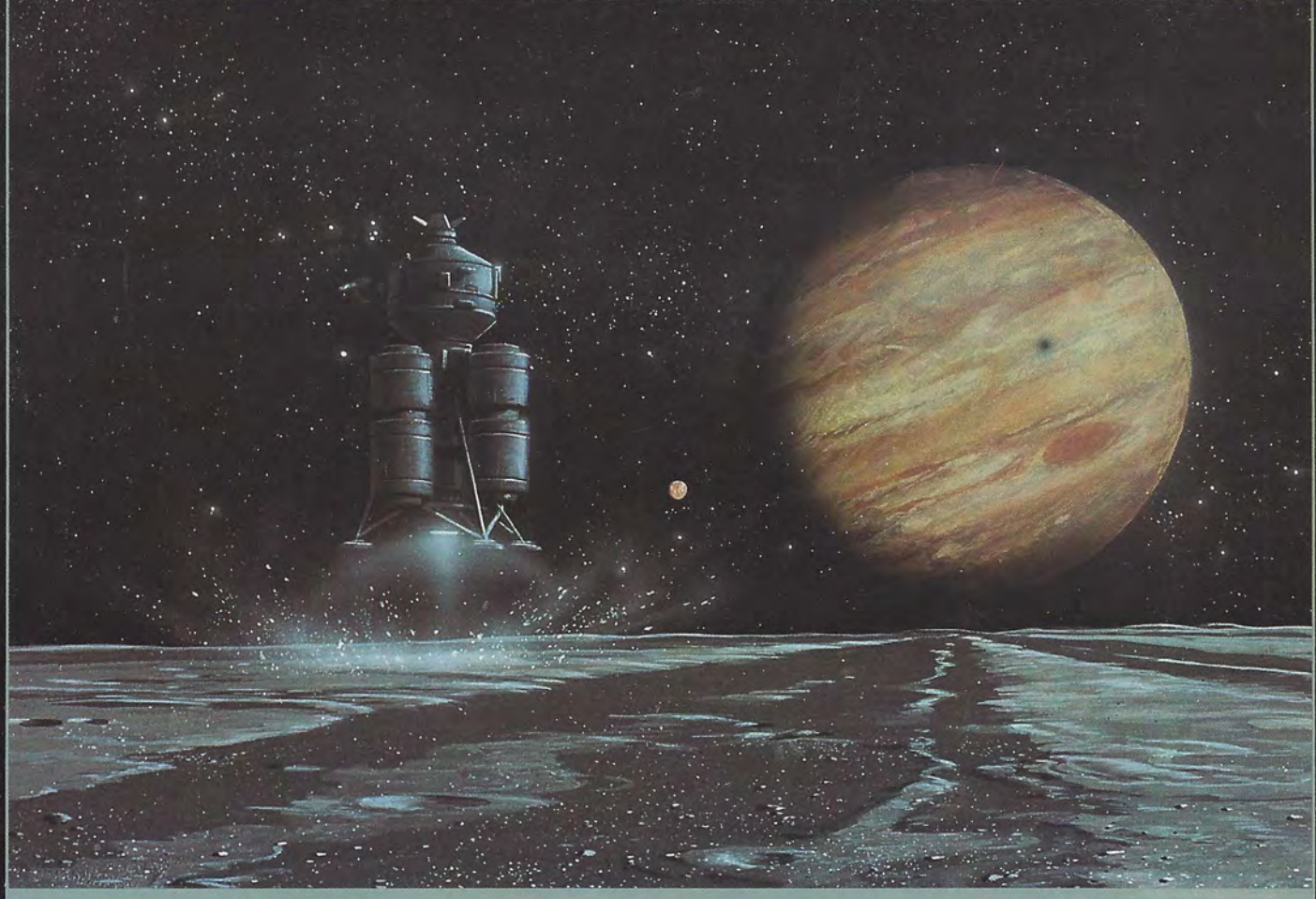
For faster service on credit card orders:
Phone: 8 A.M. – 5 P.M. (Pacific Time)
(818) 793-5100

Sales Tax:
California residents add 6%.
Los Angeles County residents add an additional ½% transit tax.

Foreign Orders add $4.00 for shipping and handling.

Total Order:

Officers of The Planetary Society do not receive any proceeds from sales of books of which they are authors and contributors.



LANDING ON EUROPA — A spacecraft carrying a human crew is about to touch down on the pool table-smooth surface of Europa. Another Jovian moon, Io, hangs in the sky while Ganymede casts its shadow on Jupiter.

Ron Miller is the co-author of The Grand Tour, Out of the Cradle and Worlds Beyond: The Art of Chesley Bonestell, and is now completing a space science book for children. He lives near Fredericksburg, Virginia.

THE PLANETARY SOCIETY
110 S. Euclid Avenue
Pasadena, CA 91101

NONPROFIT ORG.
U.S. POSTAGE
PAID
LONG BEACH, CA
PERMIT NO. 786