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Cover: The cracked, icy face of the Jovian moon Europa intrigues scientists, who have speculated that liquid water from a subsurface ocean may seep through the cracks. The reddish cast in this false-color, high-contrast image may be due to ion bombardment and sulfur deposition from volcanic Io and/or micrometeorite bombardment of Europa's leading hemisphere (right).
Photo: Alfred McEwen, U.S. Geological Survey

Society SETI Project Named

The Planetary Society/Harvard University Search for Extraterrestrial Intelligence, underway at the Oak Ridge Observatory, now has a name: *Project Sentinel.* The winning entry was submitted by Don Lago of Columbia, Missouri, and he has won a set of six books on SETI. Mr. Lago explained his entry "incorporates the word 'SETI' and means 'one who watches.' " Serendipitously, "The Sentinel" is the name of the short story by Arthur C. Clarke which served as the starting point for the writing of "2001: A Space Odyssey." Joseph Meno of Fayetteville, North Carolina suggested the same name, but his entry arrived after Mr. Lago's.

We have five runners-up in the Name the Planetary Society's SETI Project contest:

Project Prospector was entered by both Rodney F. Seeland of Mt. Pleasant, Michigan and Barry Belian of League City, Texas. Mr. Belian explained that "Just as a prospector must sift through millions of grains of sand and dirt, the search for extraterrestrial intelligence involves sifting through the millions of stars in the heavens, as well as millions of frequencies for each one."

Project Sift was submitted by Bruce Satta of Columbus, Ohio, who wrote that this name suggests "the examination of many narrow-band channels in the vicinity of the magic frequency: a 'sifting' of the radio spectrum."

Project Acorn was suggested by Mark Mitchener of Mooresville, Indiana, who said that this name "honors the Oak Ridge Radio Observatory. It also suggests the large number of channels being listened to; oak trees bear a large number of acorns, some of which are ripe, some of which are not." And mighty oaks from tiny acorns grow.

Project Sherlock, submitted by Sam Yassine of Arcadia, California needs no explanation.

The Planetary Society received over 1000 entries to this contest. The submissions came in English, Middle English, French, Spanish, Latin, Greek, Egyptian, Hebrew, Hindi, Cree and "Elvish." Many of the entries showed serious thought about the process of SETI and its possible significance. Others were humorous; two favorites of the Planetary Society staff were: *Deep Peep,* from Bruce L. Hasslinger of San Diego, California; and *ET & T,* sent in by Lance, whose last name and address we couldn't read. Several names were taken from literature and mythology, such as *Project Ariel,* from Shakespeare's *The Tempest,* suggested by Debra D. Carey of Eugene, Oregon, Mildred Schiff of West Chester, Pennsylvania, and Mrs. Michael B. Maura of Miami, Florida. *Project Heimdall* was submitted twice, by Patrick J. Gibbs of Flint, Michigan, and by the noted science fiction author Poul Anderson, who wrote:

"This figure, out of Norse mythology, was the watchman of the gods. According to the *Younger Edda,* he kept his post at the end of heaven, needed less sleep than a bird, could see both by night and by day, could even hear the grass growing. When he sounded his horn, it was heard throughout all the worlds. Even the nine mothers he is said to have had might be considered appropriate, as symbolizing the many different concepts and technologies which go together to make SETI possible."

Two members, Polly Brooks of Phoenix, Arizona and Geraldine Archibald of Edmonton, Alberta, noted that Seti (sometimes written Sethi) was the name of a great Egyptian pharaoh, and suggested our project be called, simply, *Project Seti.*

Not all entries indicated support for the project. Gareth Wynn-Williams of Honolulu, Hawaii, suggested *DUMBO,* the Drive to Uncover Messages of Biological Origin. He added, "Dumbo was a white elephant with extremely large ears."

Several names were submitted over and over; we received numerous entries for *Ears, Eavesdrop* and *Starscan.* A few of the more memorable names were: *Rosettascan*—Thomas G. Cave, Jr., Sedalia, Missouri; *Anticipation*—Larry Schaeffer, Guelph, Ontario; *Big 10-4 Cosmic Buddy*—Jacqueline Falbo, San Antonio, Texas; *Horton* (from Dr. Seuss' *Horton Hears a Who*) —Captain Ira M. Norman, Kirtland Air Force Base, New Mexico; *Knock-Knock*—Tom Monticue, Riverside, California; *Oz*—Robert A. Baum, Woodland Hills, California; *Stellar Yeller*—Peter Passick, Muskego, Wisconsin; *Ameche*—Toni Reinhold D'Amato, Brooklyn, New York; *Clark Gable* (for big ears) —W. Gregory Stewart, Los Angeles, California; *Godot* (*Waiting for...*) —Susan M. Tolman, Raleigh, North Carolina; *Scouring Pad*—Patrick A. Franklin, Indianapolis, Indiana; *Oasis*—Alex Nauda, Lewisburg, Pennsylvania; *Say Again*—Clarence Terry, Inverness, Florida. □

In Praise of Arthur C. Clarke

by Carl Sagan

When I was in high school I knew that I was interested in the other planets and I knew that rockets had something to do with getting there. But I had not the foggiest notion about how rockets worked or how their trajectories were determined. Then I came upon an advertisement for a book called *Interplanetary Flight* by one Arthur C. Clarke. You must remember that at this time there was hardly any respectable non-fiction literature on the subject. I sent away my money and breathlessly awaited the arrival of *Interplanetary Flight*. It was a modest-looking book, beautifully written, its stirring last two paragraphs (see box) still of great relevance today. But the part about it that was most striking for me was the discussion of the gravitational potential wells of planets and the appendices which used differential and integral calculus to discuss propulsion mechanisms and staging and interplanetary trajectories. The calculus, it slowly dawned on me, was actually useful for something important, and not just to intimidate high school algebra students. (In New Jersey high schools, around 1950 at any rate, integrals were considered not so much mathematical conveniences as objects of religious awe.)

The flyleaf informed me that Mr. Clarke was connected with something called The British Interplanetary Society. The very existence of a British Interplanetary Society helped to convince me that the subject was not entirely disreputable, as almost all my friends and acquaintances were fond of suggesting. Back copies of the *Journal* of the BIS were stocked in the rundown Manhattan offices of the still fledgling American Rocket Society (later the American Institute of Aeronautics and Astronautics), and through the kindness of Billy Slade, the Society's secretary, I was able to make off with some back numbers filled with marvelous ideas—including an electrical propulsion scheme by Clarke, very similar to Gerard O'Neill's "mass driver." As I look back on it, *Interplanetary Flight* was a turning point in my scientific development and I would like to take this opportunity to thank Arthur publicly for this splendid book.

Since then I've had many opportunities of meeting with him. Arthur has introduced me to both the composer of "Tubby the Tuba" and the producer of "2001: A Space Odyssey." We attended the New York World's Fair of 1964 together. I can remember being very annoyed at a free film offered by the Moody Bible Institute claiming that the reproductive behavior of the California grunion was proof of divine intervention, when it could so easily be understood in terms of natural selection. I complained to a cherubic usher who undoubtedly had limited responsibility for the film's mystical orientation, but Arthur chided me gently: "It's not as if we had paid admission," he reminded me.

I may have been of some little help to Arthur over the years, for example, with the end of the movie "2001"; and the ideas in such stories as "A Meeting with Medusa." But what Arthur has done for me is vastly greater. Through his non-fiction books and his science fiction stories and novels, his invention of the communications satellite, his defense of reason against the clamors of superstition, his work in more finely honing the British Interplanetary Society, and through his classic motion picture, Arthur has done an enormous global service in preparing the climate for a serious human presence beyond the Earth. I hope that the governments of our epoch will have the sense to continue making Arthur's dream—shared by so many of us—a reality.

Carl Sagan is the David Duncan Professor of Astronomy and Space Sciences and the Director of the Laboratory for Planetary Studies at Cornell University.

Arthur C. Clarke and Carl Sagan gave two of the three keynote addresses at the United Nations' UNISPACE conference, held in Vienna in August 1982. The third address was given by Oleg Gazenko of the Soviet Union.

Excerpt from Interplanetary Flight
by Arthur C. Clarke

The dream of flight was one of the noblest, and one of the most disinterested, of all man's aspirations. Yet it led in the end to that silver Superfortress driving in passionless beauty through August skies towards the city whose name it was to sear into the conscience of the world. Already there has been half-serious talk in the United States concerning the use of the Moon for military bases and launching sites. The crossing of space may thus bring, not a new Renaissance, but the final catastrophe which haunts our generation.

That is the danger, the dark thundercloud that threatens the promise of the dawn. The rocket has already been the instrument of evil, and may be so again. But there is no way back into the past: the choice, as Wells once said, is the Universe—or nothing. Though men and civilisations may yearn for rest, for the Elysian dream of the Lotos Eaters, that is a desire that merges imperceptibly into death. The challenge of the great spaces between the worlds is a stupendous one; but if we fail to meet it, the story of our race will be drawing to its close. Humanity will have turned its back upon the still untrodden heights and will be descending again the long slope that stretches, across a thousand million years of time, down to the shores of the primeval sea.

A Talk with Arthur C. Clarke

Arthur C. Clarke, author and scientist, achieved world renown for inventing the geosynchronous communications satellite and for co-writing the film, "2001: A Space Odyssey". His latest book, 2010: Odyssey II, is on the best seller lists. The possibility of life on the Jovian moon Europa is a major theme of this new work. Dr. Clarke recently chatted with James D. Burke after a tour of the Jet Propulsion Laboratory.

James D. Burke: What is your reaction to what has been achieved so far in planetary exploration?

Arthur C. Clarke: JPL is the spearhead of space exploration. What has been happening here in the last two decades is absolutely stunning, unbelievable even to people like myself who hoped that it would happen but never dreamed it would happen in our lifetimes.

JDB: You not only hoped that it would happen, you did very important things to make it happen.

ACC: Thank you. I'm one of many pioneers, most of whom have gone. I sometimes feel like a survivor, and yet I'm happy that most of them did see this happen. The most amazing survivor of all, of course, is Hermann Oberth, who is still alive and who wrote about all this in the 1920's when it seemed even more ridiculous and absurd than when I started writing about it in the 1930's. One other comment I'd like to make is this: I feel that the disinterest, indeed, hostility to the space program has at last bottomed out, if that's not a mixed metaphor. There are several indications of this. In my own field, I was very interested to see that on *The New York Times* fiction best seller list, five of the first twelve books are about space, including Michener's *Space*, Asimov's *Foundation's Edge* and my *Odyssey 2*.

Odyssey 2 was made possible by JPL and, specifically, by the *Voyager* spacecraft. When Stanley Kubrick and I wrote *2001*, the moons of Jupiter were just points of light even with the most powerful telescope. We never imagined that we would know anything about them before our spacecraft, *Discovery*, flew to them in 2001. And yet, only a dozen years later, those points of light became worlds in their own right, thanks to the incredibly successful *Voyager* missions. I said in a television interview this morning that I owe about $1 million to *Voyager*.

JDB: Well, *Voyager* certainly owes some things to you. I'd like to know your thoughts on what to me is the most puzzling conundrum in the space program right now. We have a scheme laid out for what we want to do next among the planets, and of course applications near Earth are going in all directions. But what about the Moon? It's up there looking at us all night and nobody knows what to do about it.

ACC: None of us science fiction writers ever predicted, first, that men would get to the Moon as early as 1969 and second, that they would abandon the Moon as early as 1972. That does seem quite incredible. Obviously, we're going back to the Moon and equally obviously, one of the first things we should do is have a polar orbiter that will give a really good survey of the Moon with the use of the wonderful new Landsat techniques which, as we were shown during our tour of JPL today, enable us to identify minerals on the face of the planet hundreds of kilometers below. The case for a really detailed geophysical and geological survey of the entire lunar surface is overwhelming. That's the first thing we have to do. Such a survey might reveal water ice and useful minerals and tell us where we should go for the next landing. Then the momentum will build up to do that. And of course as the Space Shuttle matures, it will make it easier to get a manned lunar expedition together, perhaps by aggregating equipment, fuel and supplies while in orbit, so it will not have to be one enormous launch effort, as was each *Apollo* mission.

JDB: You expect that it can grow out of an orbital establishment?

ACC: Yes, and you would recover the spacecraft by aerobraking into Earth orbit so it won't just come crashing into the atmosphere and ocean.

Also, I hope you can get the Venus radar orbiter going because Venus is a fascinating place, although not a very desirable piece of real estate. But I'm beginning to get more and more interested in Europa. I have a feeling that Europa may be where the action is.

JDB: We'll look forward to finding out whether, as has happened before, the future does what you want it to do.

ACC: On to Europa! □

Below: The Jupiter-bound spacecraft Discovery from the film "2001: A Space Odyssey," co-written by Arthur C. Clarke and Stanley Kubrick.

THE SOLAR SYSTEM'S OTHER OCEAN

BY STEVEN W. SQUYRES
AND RAY T. REYNOLDS

To many of us, *Voyager*'s first images of Europa looked like the work of an imaginative science fiction artist. To those familiar with satellite pictures of the Earth, however, some of the patterns on Europa were startlingly familiar: The highest resolution photos look much like satellite images of arctic sea ice. This observation by itself is not very significant, since nature has a way of producing superficially similar forms by very dissimilar means. Recent theoretical work suggests, however, that there is in fact a liquid water ocean beneath Europa's icy crust. This view is supported by a more detailed look at the evidence from *Voyager*.

By now many people know about the intense volcanic activity on Io, the innermost large satellite of Jupiter. The heat source driving the vulcanism is called tidal dissipation. This same heat source operates on Europa as well. Europa's orbit around Jupiter is not perfectly circular. Gravitational tugging by other moons distorts Europa's path slightly, so that its distance from Jupiter varies continually during the course of an orbit. The enormous gravity of Jupiter distorts Europa's shape, raising a tidal bulge. Because the distance from Jupiter varies, the gravitational attraction and hence the size of the bulge vary as well.

With each orbit Europa is stretched back and forth very slightly. This flexing heats Europa, just as a piece of coat-hanger wire is heated by →

THIS COMPUTER MOSAIC OF THE BEST IMAGES FROM VOYAGER 2 SHOWS HOW EUROPA'S SURFACE IS CRISS-CROSSED WITH DARK AND LIGHT CRACKS.

PHOTO: JPL/NASA

RIGHT: VOYAGER 1 PROVIDED ONLY A TANTALIZING HINT OF THE ELABORATE NETWORK OF CRACKS THAT MARKS EUROPA'S SURFACE.

BELOW: EUROPA HAS VERY FEW IMPACT CRATERS, IMPLYING THAT ITS SURFACE IS CONTINUALLY REWORKED BY SOME GEOLOGIC PROCESS.

PHOTOS: JPL/NASA

bending it back and forth rapidly. The heating is much less than for Io, but calculations suggest that it is sufficient to maintain most of the water in Europa in a molten state, creating a liquid water ocean several tens of kilometers deep covered by an ice shell that may average as little as a few kilometers in thickness.

A Fractured Shell

This thin ice shell will be very susceptible to fracture, and in the *Voyager* images we saw evidence for extensive fracturing. When a fracture occurs, liquid water may be briefly exposed at Europa's surface. With no atmosphere above it, this water will boil violently, and at the same time will freeze. There is no paradox here—as boiling occurs and vapor is lost, the vapor carries away with it a great deal of heat. The heat loss is sufficient to freeze a half-meter-thick layer of ice that shuts off the boiling in only a few minutes. Most of the vapor that boils away is not lost to space, but recondenses on the surface as frost at distances of up to hundreds of kilometers from the original fracture.

There is strong evidence for this type of frost deposit on the surface of Europa. The surface is very bright, and spectra show it to be nearly pure water. It scatters light in the manner expected for a very fluffy frost deposit. The lack of craters on Europa gives evidence for relatively warm subsurface temperatures allowing glacier-like flows of the icy crust after a crater-forming impact. Warm temperatures in the crust could be maintained if an insulating blanket of low conductivity frost traps Europa's heat below.

Important evidence for frost deposition comes from observations of Europa by the Earth-orbiting International Ultraviolet Explorer spacecraft. These observations reveal that only minute amounts of sulfur are mixed in with Europa's surface frost. Yet, electrically charged sulfur originating on Io and trapped in Jupiter's magnetic field is continually bombarding Europa. Unless frost were continually being deposited along with the sulfur, the sulfur would be observed in much higher concentrations. From the observed sulfur concentrations we infer that frost from vapor eruptions is being deposited on the surface of Europa at an average rate of at least ten centimeters per million years.

An Abode for Life?

There is considerable evidence, then, that beneath the ice on Europa lies the solar system's second ocean (second only in order of discovery—it probably existed before ours did). Its volume, within the limits of our ability to calculate it, is about that of the Earth's oceans. Given the known affinity of terrestrial life forms for a watery environment, it is natural to consider the suitability of this proposed ocean as an abode for life.

The temperature and pressure in the ocean should be quite favorable for simple life forms, and it is unlikely that the chemical environment would present any major obstacles. The principal stumbling block is, of course, the lack of a powerful energy source. Only a tiny amount of the sunlight striking the surface of Europa could filter down through cracks in the ice shell.

Yet even this small amount might be sufficient to support very primitive biologic activity for limited periods. For example, there are algae that live at the bottom of permanently ice-covered lakes in Antarctica. During the brief Antarctic summer these algae receive

THE *GALILEO* SPACECRAFT WILL SWING BY THE JOVIAN MOON EUROPA SEVERAL TIMES AFTER IT HAS EJECTED A PROBE INTO JUPITER'S ATMOSPHERE. *GALILEO* WILL MONITOR THE MOON OVER AN EXTENDED PERIOD AND THE DATA IT RETURNS COULD DEMONSTRATE WHETHER OR NOT EUROPA HAS AN OCEAN OF LIQUID WATER BENEATH ITS ICY SURFACE.

PHOTO: JPL/NASA

light that penetrates through the ice and photosynthesize so vigorously that they produce oxygen bubbles which actually lift them from the lake bottom. The light levels at which this photosynthesis takes place could exist immediately beneath a fracture on Europa for perhaps five to ten years after fracturing.

Another environment with potential significance for Europa is found at hydrothermal vents on the Earth's ocean floor. There, sulfur compounds produced at very high temperatures are metabolized by bacteria in a process known as chemosynthesis. These bacteria form the base of a very diverse local food chain. If there is submarine volcanic activity on Europa then it could be an important energy source there as well. We can calculate the amount of heat that comes from Europa's rocky interior. It is more than that produced by the Earth's Moon, but less than that produced by the Earth. The Earth is of course volcanically active, while the Moon presently is not. Europa lies somewhere in between, and we unfortunately cannot accurately predict whether or not volcanic activity actually occurs on Europa's ocean floor.

Not A Tropical Paradise

Europa is not a tropical paradise. However, it may contain local environments, very limited in space and time, that would be capable of supporting simple forms of life. That is not the same as saying that life could have evolved there originally. The creation of life in a lifeless environment probably requires much more energy than is needed to support simple life forms that already exist. Nonetheless, Europa may be one of the best places in the solar system to search either for life or for the primitive conditions that could lead to it if only enough energy were present.

Tempting though it is, the next logical step in the exploration of Europa does not involve scuba divers or submarines. The *Voyager* data do not even conclusively show that an ocean exists there—they merely suggest it. The way to prove that an ocean exists would be to actually observe the puff of vapor that would be produced by fracturing of the crust. This might be possible using Earth-based infrared telescopes if the puff were large enough. More likely, though, would be the possibility of actually observing this short-lived cloud of ice crystals and vapor from a spacecraft near Europa at the time of the eruption. This opportunity will be presented when NASA's *Galileo* orbiter arrives at Jupiter in 1988. *Galileo* will be able to monitor Europa for an extended period of time, and could provide the conclusive evidence that shows whether or not Europa, like the Earth, has an ocean of liquid water.

Steven W. Squyres and Ray T. Reynolds are researchers at NASA's Ames Research Center in Mountain View, California. This work was done in conjunction with Patrick Cassen, David Colburn and Christopher McKay at Ames, and Stanton Peale at the University of California at Santa Barbara.

Planet-Building by Computer

Media coverage of the Voyager *encounters with Jupiter and Saturn made the faces of these distant planets and their moons familiar to millions of people across the country and around the world. Nightly television news programs broadcast detailed images of turbulent atmospheres, erupting moons and braided rings into thousands of living rooms. Although the images returned to Earth by the spacecraft are remembered for the beauty and mystery they revealed, it was the computer graphics animation of the spacecraft sweeping through the planetary systems that captured the imagination.*

The films were produced at the Jet Propulsion Laboratory by Dr. James F. Blinn, whose pioneering work in computer graphics and animation is helping to revolutionize the film industry. Space artist Jon Lomberg and our editor Charlene Anderson talked with Dr. Blinn about how he builds images of planets by computer.

Jon Lomberg: *What is a computer graphic?*

Jim Blinn: It is basically a computer-made picture. It puts the picture into a lot of little dots and figures out how much light would pass through each dot. The computer can simulate a viewer looking at a particular scene by, in effect, running light rays backwards from the viewer's eye to the planet. It picks a particular dot on the screen and extends it out into space. It does that over and over again for all of the dots on the screen.

Then, after "viewing" the planet, it has to figure out what color to make the dots. The computer does that by calculating the latitude and longitude of the surface of the planet that can be seen through that particular dot and comparing that with a map of the coloration of the planet. It figures out the orientation of the surface according to its relation to the Sun.

JL: *You keep saying "It does this," and "It does that." What do* you *do?*

JB: "It" is the computer and it is going through a lot of arithmetic. What I do is set up the steps of arithmetic in the proper sequence. It plugs in the numbers and does the adding and subtracting. The final result will be a number which represents the intensity of a certain dot at a particular point.

JL: *Let me ask you in a little more basic way about how numbers make pictures. If you want to put a straight line or a wavy line on a screen, what do you do?*

JB: Basically, numbers are related to pictures through analytic geometry, one of the great mathematical inventions of the 1600s. Geometry was combined with algebra through great philosophical insight on the part of Descartes and others. It involves measurements. A location on the screen is represented by two numbers — the horizontal distance from the edge and the vertical distance from the top. That defines the position.

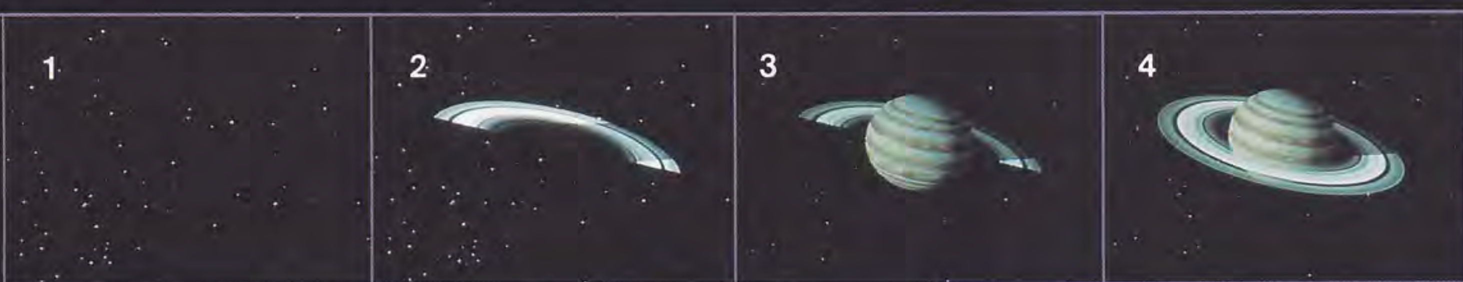
Various mathematical equations define shapes. A simple equation defines the shape of a straight line. You give the computer two points on a line and it will figure out the points in between them. Things like circles have slightly more complicated equations, but again you can plug in the numbers and trace a line around the edge of the circle. In three dimensions you have three numbers instead of two. You have horizontal, vertical and depth. An equation will define the shape of a three-dimensional solid. For example, the shape of a sphere is simple; planets are among the easiest things to draw because that is simple for the computer to do.

JL: *What about color?*

JB: Color is generally represented on the screen by three numbers. A black and white image is one number based on brightness. Zero means black, one means white, one-half means gray, three-fourths means lighter gray. For color you have three color primary values. If you look very closely at a color TV set you will notice the red, green and blue dots that make up a three-color primary picture. That is related to how the human eye sees color. Our eyes separate the white light they see into three categories: red, green and blue. Creatures on another planet might have four color primaries, or two, or even eighteen. Humans happen to see three primary colors, so color television can work with three images. To make a color image on the computer, you compute three numbers instead of one. It is like doing three different pictures of the same geometric situation and overlaying the red, green and blue to make the other colors.

Charlene Anderson: *How do you get motion?*

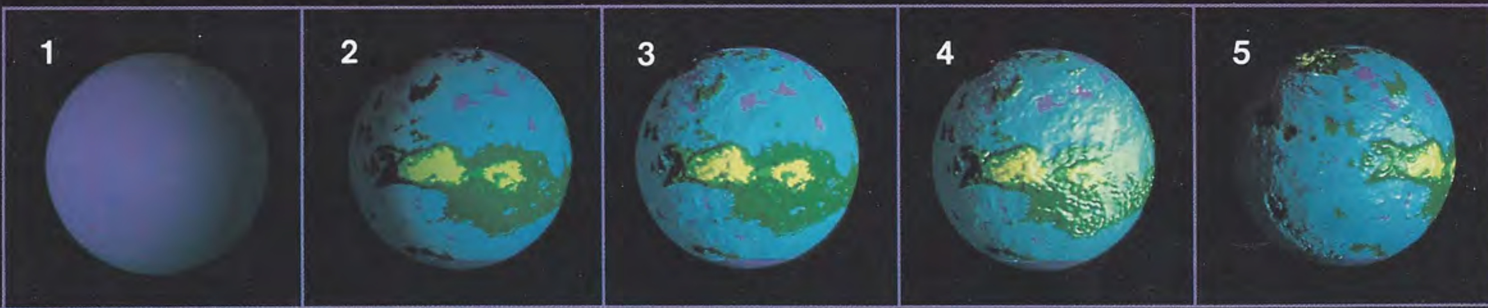
JB: You get motion in much the same way



IMAGES: DR. JAMES F. BLINN

ABOVE: THESE IMAGES WERE GENERATED BEFORE THE VOYAGER 1 ENCOUNTER WITH SATURN, WITH LITTLE DETAIL IN THE RINGS AND ATMOSPHERE. THE COMPUTER FIRST DISPLAYS A STARFIELD IN 1, THEN RINGS ARE ADDED IN 2, THE PLANET APPEARS IN 3, AND IN 4 THE RINGS ARE CLOSED. ■■ RIGHT: USING VOYAGER DATA PROVIDED BY CHARLES KOHLHASE AND THE PROJECT TEAM, DR. BLINN WAS ABLE TO CREATE THIS DETAILED IMAGE OF SATURN AND THE SPACECRAFT.

BELOW: THE PIONEER VENUS ORBITER PROVIDED THE RADAR DATA FROM WHICH THESE IMAGES OF THE PLANET WERE CONSTRUCTED. IN 1, THE COMPUTER GENERATES A SHAPE, COLOR IS ADDED IN 2, 3 HAS TEXTURE, 4 ADDS REFLECTED LIGHT, AND IN 5 THE PLANET IS SET IN MOTION.



IMAGES: DR. JAMES F. BLINN

that traditional movie animation does, by having the computer make a lot of different pictures one after the other, slowly varying some of the numbers. Whenever you make a particular image, a set of numbers determines what direction you are looking toward, the field of view of your simulated camera, your position in space, and the time and date, so that the positions of the moons and spacecraft can be calculated.

Something like 20 different numbers will determine the appearance of that particular frame in the movie, and to make the thing animate, you make a table of numbers for printing the picture at time zero. You figure out another set of numbers for time 200 and enter 20 numbers for that. You slowly vary the values of each element of the picture from zero to 200. You will see your viewing position slowly swing to the right as the computer interpolates, as it is called, the values of the viewing direction number. For example, if you simply wanted to move a sphere on the screen, what would you do? You'd give it one position, the horizontal and vertical distance expressed in two numbers, then give it another position at a different horizontal and vertical distance, and the computer will move 1/100 of that distance, or 2/100 or 3/100, etc. It will appear to move along a straight line.

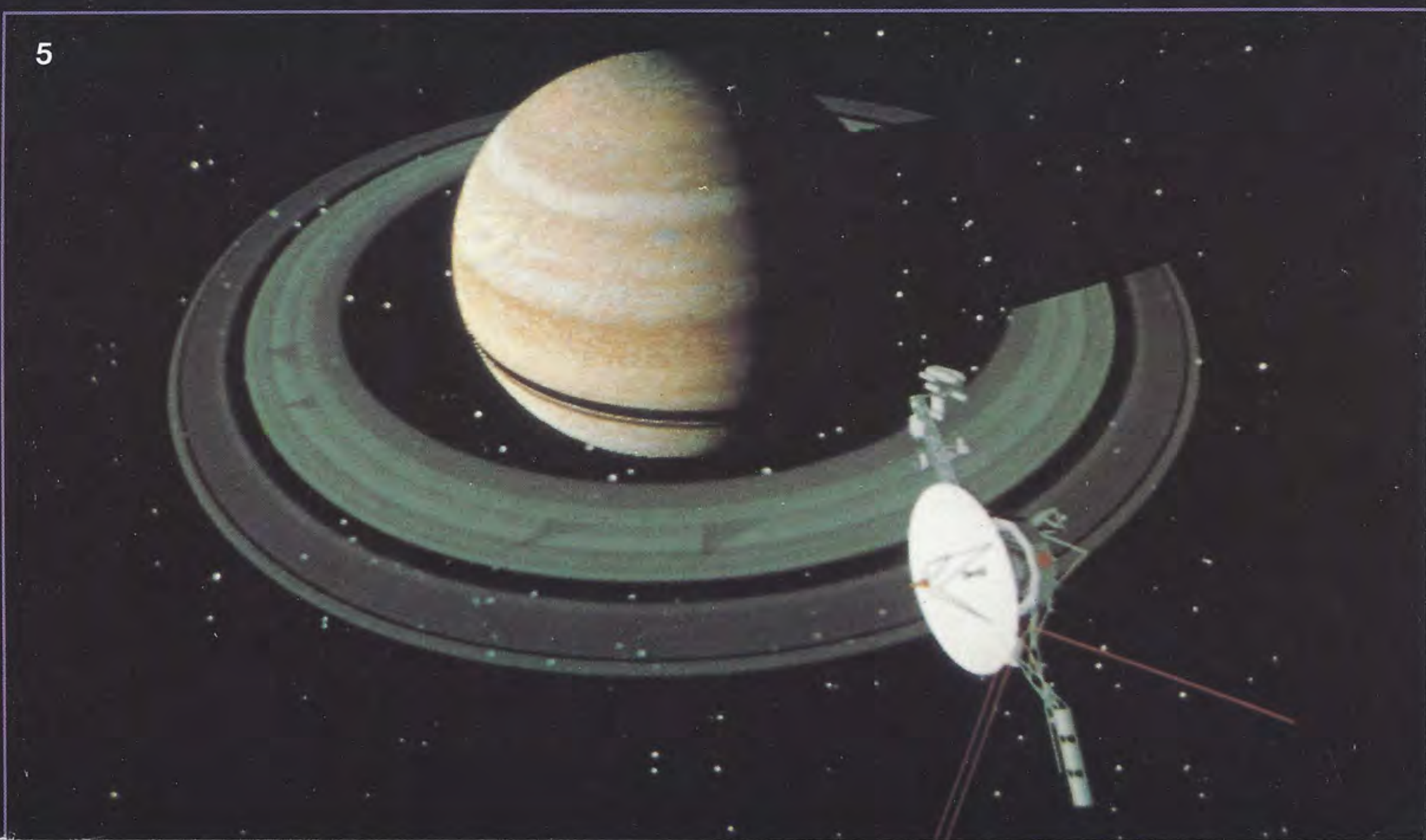
JL: *That is line, color, movement. What about light?*

JB: Basically, to simulate light involves the reading of a bunch of textbooks on physics to see how light interacts with substances. When light hits a surface, the surface will reflect it in varying amounts and in different directions. If you are looking from a particular direction at a surface, you must calculate how much light hits the surface at this angle, how much of it gets reflected at the angle that the eye is looking from.

From simple surfaces — for example, felt or cloth — the light hits the surface and is reflected equally in all directions; it doesn't matter what direction you are looking in, you will see the same brightness. So if the light hits perfectly

(continued on next page)

IMAGE: JPL/NASA



perpendicular to the surface, it is very concentrated. If the light hits at an angle to the surface, the light will be spread over a larger area and the surface will look dimmer. Similarly, in the Earth's northern hemisphere, it's cold in the winter and warm in the summer because the Sun's light hits more perpendicularly in the summer; it is more concentrated. It hits us on more of a slant in the winter. Saturn, whose visible surface is mostly clouds, perfectly diffuses light because the varied cloud particles scatter light in all directions.

Very hard surfaces like mirrors don't scatter light at all but reflect it in a perfect beam, like bouncing a ball off the floor. You have equal angles of incidence and reflection. So, if you're simulating a mirror, you figure out in what directions the light will be reflected, and if that's the direction of your eye, you'd see all the light. In any other direction you won't see any light. That is how the computer simulates highlights. It figures out the direction of reflection, and how far away the viewer is, and determines the light depending on that distance.

CA: *How do you "draw" a planet?*

JB: Well, Saturn is the most interesting one to draw, because it has the rings. Drawing pictures of planets is as much gathering data as it is writing programs. For example, I started drawing Saturn in two pieces: the surface, where the clouds form light and dark patterns; and the rings, and the light and dark patterns within them. So, we started out with a rough idea and had to fill in the gaps somewhat artificially. We constructed a very basic map of the surface features, with light and dark streaks across it. As the various spacecraft flew by Saturn, they sent back more and more details of what that planet looks like, so I have been able to update and enhance the data base.

When we get the data back, they are generally in a form not immediately convenient for making pictures. You have to make it into an intermediate form. The program that draws the planet requires a map of the surface, like a Mercator map of the Earth. The equator goes through the middle and there are poles at the top and bottom. You have to do reverse graphics by taking a photograph of the real planet, running that through the reverse process which takes the picture and stretches it into the map projection. Each picture gives you only a part of the map. So, you have to put together several different pictures to make a map of the real surface features.

With the rings of Saturn, the light and dark patterns are places where there is lots of stuff or not much stuff, ice particles or a very thin distribution of these particles. There's a simple equation that transforms the brightness into the density of the ring particles. What I do is to take an image sent back by a spacecraft and have the computer measure the brightness of the rings at each radius, and feed it through its equation into a number for particle density. Once this is done, we have basically a table of how many particles there are at different distances from Saturn. So the ring drawing program uses that table to figure out how bright the particles should be at a desired distance and a desired viewing direction and Sun angle.

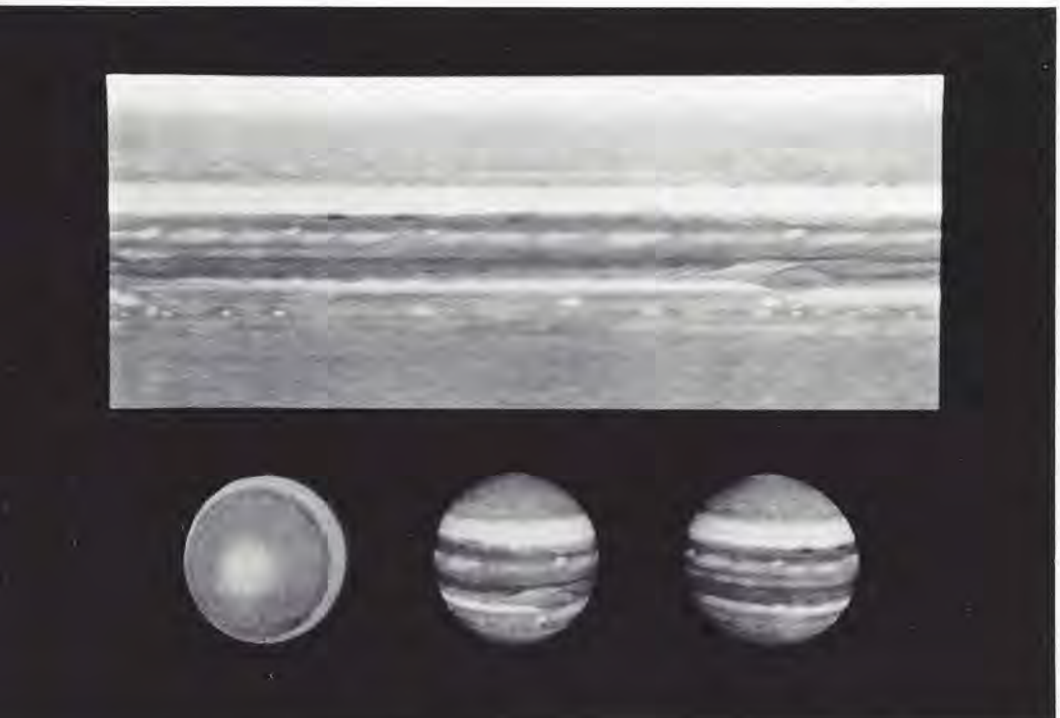
So, it can simulate variations in the light as you look at Saturn's rings. The rings as you normally see them are almost edge on, so they look more dense. If you look down on the north pole of Saturn, they would look a lot fainter because you're seeing a thinner cross-section of the rings. Also, when you look at the rings from the Earth, the Sun is behind you and light bounces off the ring particles and reflects back at you. If you are looking from the north pole of Saturn, the light comes in from the side and most of it gets reflected back towards the Earth. Not much of it would be reflected vertically. All of these things can be reduced to mathematical equations which are used to calculate intensity as a function of viewing position and direction.

CA: *How do scientists use the movies of the planet rotating?*

JB: The films that I make are not so much for scientific research as for public information. The scientists look at them just to see what's going on, because it's always fun to see your particular thing animated. It hasn't been used a lot for mission planning, although it might be in the future.

We have used it for some small scale mission planning. For example, Lonne Lane (of the *Voyager 2* photopolarimeter experiment) has come down here and used the programs to design star occultations. The main star occultations were set up by finding a star that was going to disappear behind the rings of Saturn, so the rings would block out the light from the star. After measuring the brightness of the star, it was possible to tell how much stuff is in the rings. They already knew the star that they wanted to use, but when they came down here and played around with the computer graphics they saw some other stars going behind the rings, and they were going to try to do some other measurements with them. But the spacecraft scan platform malfunctioned and stopped them.

But now that *Voyager 2*'s going out to Uranus, they've been down here and we've been watching the stars go by behind that planet. I use the real star locations as the data base; they are fairly easy to get. I try to put in more details to make a visual impression. You have to be careful, though, because computer graphics were not designed as a design tool. When somebody comes down and sees something happening on the screen, I have to make sure that I've really done it right. □



INFORMATION FROM SEVERAL DIFFERENT PICTURES CAN BE FED INTO THE COMPUTER WHICH STRETCHES THEM INTO A MAP PROJECTION. THE MAP CAN THEN BE REASSEMBLED INTO SPHERICAL FORM TO CREATE AN IMAGE OF THE ENTIRE PLANET.

WORLD WATCH

A New Golden Age of Planetary Exploration?

by David Morrison

This issue's World Watch is a guest column on the planning of the American planetary exploration program. The Solar System Exploration Committee (SSEC), a NASA advisory group, has developed a plan for U.S. missions to explore the solar system through the end of the century. Dr. David Morrison, chairman of the SSEC, reports here on this proposal. A summary of the SSEC report, Planetary Exploration Through Year 2000, *is available for $5.50. If you would like a copy, please send your check to: SSEC Report, The Planetary Society, P.O. Box 91327, Pasadena, CA 91101.*

During the 20 years from the first *Mariner* flyby of Venus to the *Voyager 2* encounter with Saturn, planetary exploration experienced its first Golden Age. More than 40 robot spacecraft probed first toward the Moon, Venus and Mars, then ultimately to every planet known to ancient peoples, from Mercury to Saturn. The United States launched most of these spacecraft bearing names symbolic of their exploratory missions: *Ranger, Surveyor, Pioneer, Mariner, Viking* and *Voyager*. The Soviet Union, the other nation to contribute to this era of discovery, focused its efforts on the Moon, Venus, and Mars but it, too, achieved remarkable successes. Within less than a generation, humans discovered more than two dozen new worlds, placing our planet for the first time in its cosmic context.

In spite of this brilliant beginning, planetary exploration has fallen upon hard times. No new NASA missions have been initiated since 1977, when the *Galileo* orbiter and probe of Jupiter was authorized. A little more than a year ago, the administration in Washington seriously considered ending the U.S. planetary program. Planetary scientists, NASA managers and space advocates in Congress and elsewhere have realized that we must take a fresh look at our way of doing business and, if possible, develop a means of exploring the solar system that is more in tune with current and projected space budgets.

For two years, many leaders of the planetary community have worked within this perspective to develop a plan for planetary missions through the year 2000. They began this task late in 1980 at the request of then NASA Administrator Robert Frosch, who established the Solar System Exploration Committee (SSEC) of the NASA Advisory Council. This spring the first part of the SSEC recommendation was completed. It is called: "Planetary Exploration through the Year 2000: A Core Mission Program," and its main conclusions are summarized here for the members of The Planetary Society.

The Goals of Exploration

During the 20 years that we have been launching planetary spacecraft, NASA has been guided by three primary scientific objectives:

- ☐ To determine the present state, origin and evolution of the solar system;
- ☐ To better understand the Earth by comparison with other planets;
- ☐ To improve our understanding of the origin of life.

These goals can best be reached by a broad exploratory approach. We cannot know *a priori* which planet or what type of investigation will provide the most fundamental insights, therefore we have given first priority to filling in the general outlines of our system. Our spacecraft have flown past five planets and dozens of moons, and landers have touched down on the surfaces of Venus, Mars and the Moon. But these successes, and the stunning images returned by our *Mariners, Voyagers* and *Vikings*, should not lull us into an overly optimistic impression of the true state of our knowledge.

Even for Mars, the best studied planet, our "ground truth" data are limited to two sites, each selected for its dullness (to ensure safe landings). In the outer solar system, with its giant gas planets, 45 of the 48 known moons and all of the ring systems, we have only the *Pioneer* and *Voyager* snapshots as these spacecraft made their brief visits to the Jovian and Saturnian systems. No spacecraft has visited Uranus, Neptune or Pluto. The surfaces of Venus and Titan remain largely *terra incognita* beneath their thick clouds. We have yet to send a spacecraft to a comet or an asteroid—perhaps the most glaring blank in our knowledge. These small, volatile-rich messengers from the distant past have not undergone the large-scale chemical and physical modification that has reworked the larger moons and planets, and they promise rewarding insights into the earliest history of the solar system.

Looking at the unfinished agenda of basic exploration, the SSEC has concluded that NASA should continue to pursue the same three goals that it has in the past. However, we recognize the increasing potential of near-Earth space for human activity. We have considered the establishment of a space station, and ultimately large-scale construction and even permanent human habitation in space. Yet for these dreams to become reality, we must better understand the resources that might be available in space, either on the Moon or among the Earth-approaching asteroids. Accordingly, the SSEC recommends to NASA that the time has come to add a fourth goal:

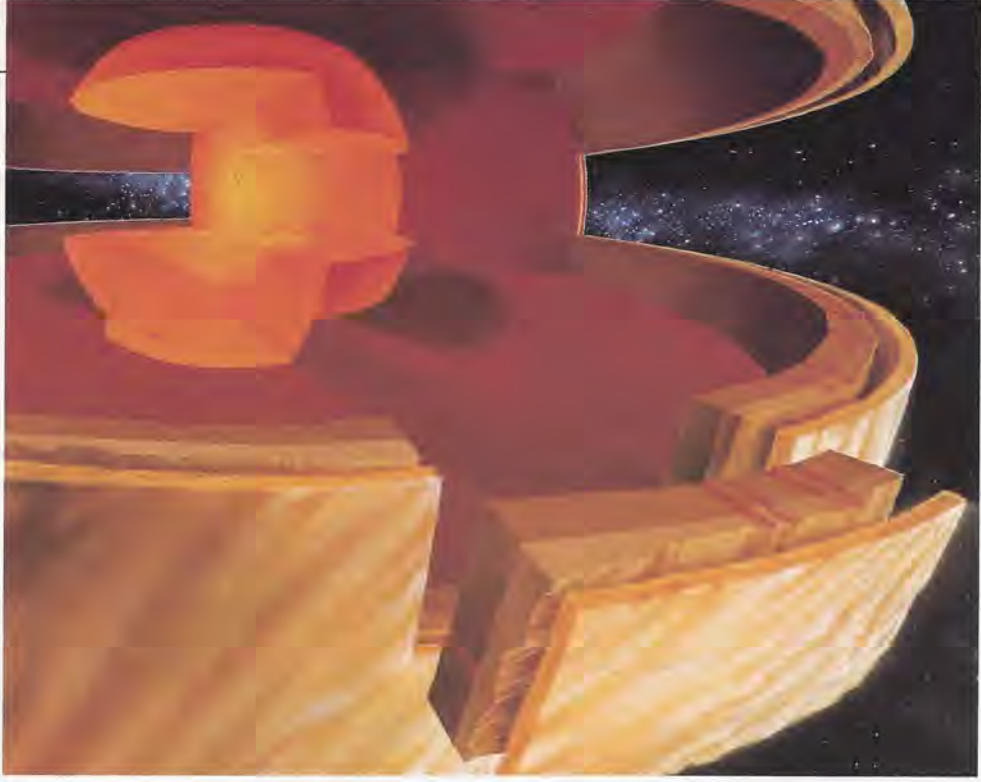
- ☐ To provide a scientific basis for the future utilization of resources available in near-Earth space.

To achieve this fourth objective, we should undertake missions to the Moon and the asteroids in the near future.

Space Hardware and Costs

Our choice of planetary missions has always depended on our technological capability. In the past, improvements in technology have led to more ambitious missions of increasing complexity, such as *Viking, Voyager* and *Galileo*. However, this "bigger and better" philosophy has conflicted with recent constrained NASA budgets: The planetary community seemed to be pricing itself out of the market. Further, a vicious cycle was developing: The long intervals between flights decreased the opportunities for cost-saving inheritance of hardware and designs from previous missions, while increasing the pressure to include the maximum scientific payload in each flight. The SSEC sought to break this cycle and increase the opportunities for new missions by reducing their individual costs and phasing them together in a more efficient way.

The SSEC concludes that the best way to control mission costs is to use inherited hardware and software from one mission to the next, and concentrate on what we already know how to do well—flybys, simple planetary orbiters and atmospheric probes—and



Above:
This speculative artist's conception of Venus shows one model which has the planet divided into a core, mantle and crust. Scientists are able to construct a wide variety of models that match the gravity data from the Pioneer Venus Orbiter. The Venus Radar Mapper will obtain the data needed to choose among these models.

Painting: Kurt Wenner JPL/NASA

avoid large-scale technology development. With these restrictions, we will have to defer some extremely interesting missions, such as a Mars rover or sample return. But a great deal of exciting science can still be carried out within a core program of frequent, but modest, missions.

Economy in spacecraft can best be achieved if we undertake planetary exploration as a continuing program rather than as episodic events. For near-Earth missions to the Moon, Venus, Mars and some asteroids, we can take advantage of spacecraft already developed by aerospace companies for commercial applications in Earth orbit. Even after being adapted for planetary missions, the costs of such spacecraft are modest by comparison with the specialized spacecraft now used for planetary exploration.

For missions to the outer solar system, to comets and main-belt asteroids, the SSEC recommends the development of a new generation of modular spacecraft. They will be as simple as possible and easily reconfigured from one application to the next. Informally known as *Mariner Mark II*, these spacecraft are presently under study at the Jet Propulsion Laboratory. Atmospheric probes to the outer planets and Saturn's cloud-covered moon, Titan, can be done using the Jupiter probe already designed for the *Galileo* mission. Finally, computer techniques should simplify the control and operation of spacecraft and the handling of the data they return to Earth.

If these cost-saving approaches are adopted, the SSEC believes that a vigorous mission program—about one launch per year—can be carried out at an annual cost of only $300–$350 million in current-year (fiscal year 1984) dollars. This is only one-third of the NASA planetary budget of the early 1970s, which reached nearly one billion dollars annually (in fiscal year 1984 dollars) during the development of *Viking* and *Voyager*.

The Core Mission Program

There are 14 missions in the SSEC core plan, conveniently divided into three groups: inner planets, small bodies (comets and asteroids) and outer planets. The first and highest priority mission is one that has been under consideration for many years: a Venus Radar Mapper (VRM). This spacecraft, to be launched in 1988, will fill in the greatest gap in our knowledge of the inner planets: the surface topography of Venus. Although hidden from normal view by thick clouds, the surface of Venus can be mapped from orbit with subkilometer resolution by synthetic aperture radar. In the Reagan administration's fiscal year 1984 budget, now being acted upon by Congress, the VRM is proposed as the first planetary "new start" since 1977.

A Mars orbiter, based on a commercial Earth satellite, is the second inner planet mission recommended by the SSEC. It should be launched in 1990, and would focus on the surface chemistry and climate of the red planet. The daily and seasonal exchange of water and carbon dioxide among the polar caps, atmosphere and soil could be studied. Later inner planet missions are: a Mars orbiter to investigate the upper atmosphere, a hard-landing Mars surface probe, a lunar polar orbiter, and an advanced Venus atmosphere probe.

The first mission to the small bodies, and the first of the *Mariner Mark II* series, will be a rendezvous with a short-period comet. By flying for months in formation with the comet, the spacecraft will detail the comet's cycle of activity as it is heated by the Sun. This mission will be a major step beyond the fast flybys of Halley's Comet planned for 1986 by Soviet, European and Japanese scientists. The other small bodies missions in the core program are flybys and orbiters to main belt asteroids and to the smaller Earth-approaching asteroids, and a simplified sample return mission to a comet.

We have given first priority in the outer solar system to a probe into the atmosphere of Titan, the remarkable moon of Saturn with its thick nitrogen-and-methane atmosphere and complex organic chemistry. Other missions are a Saturn orbiter and probes to Saturn and Uranus, as well as *Galileo*, which is scheduled for a 1986 launch and 1988 arrival at Jupiter.

While the United States could carry out all of these missions alone, we anticipate and welcome international cooperation. The European Space Agency or individual countries could do some missions, and other missions would lend themselves to joint activity. There is particular interest right now in U.S. and European cooperation on a Saturn orbiter and Titan probe.

An Optimistic Outlook

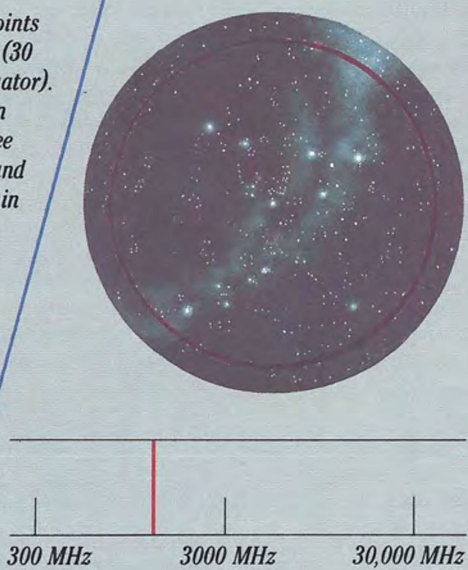
The SSEC believes that it has proposed a realistic and economical plan that is exciting nevertheless. If this plan is adopted, beginning in 1988 we will see a launch rate of planetary missions as high as that which characterized the Golden Age of the 1960s and 1970s, but it will be achieved at half the cost. We will be using new technology to hold down costs, and thereby to stimulate activity. While we can do nothing to correct the data gap of the 1980s (from the *Voyager 2* Saturn flyby in 1981 to the arrival of *Galileo* at Jupiter in 1988), we can begin now to rebuild our capability and prepare the missions that will restore U.S. leadership in the 1990s.

What I have discussed here is only a core program, limited to individually modest missions and specifically avoiding many new technological challenges. But I do not believe that our objectives should be limited to this core program, even though it seems quite rich by comparison with the currently depressed state of planetary exploration. As a great nation with ambitious long-term goals in space, we can and should be willing to undertake *Viking*-class missions, such as a Mars rover. During the 1990s, the addition of one or more of these large missions to the proposed SSEC core program would ensure a second Golden Age of planetary exploration. □

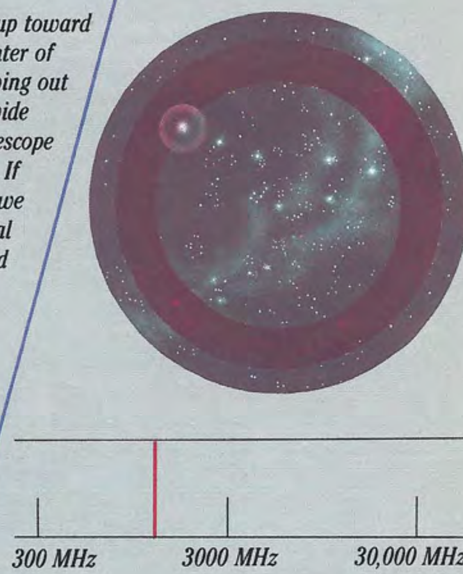
SETI Strategy

These four illustrations show the strategy of Project Sentinel, the Search for Extraterrestrial Intelligence (SETI) now under way at Harvard University's Oak Ridge Observatory. Dr. Paul Horowitz is directing the project, which is funded by The Planetary Society. The red bands mark the area of the northern sky covered by the search. The microwave region of the electromagnetic spectrum is indicated below the star map, showing the frequencies already monitored.

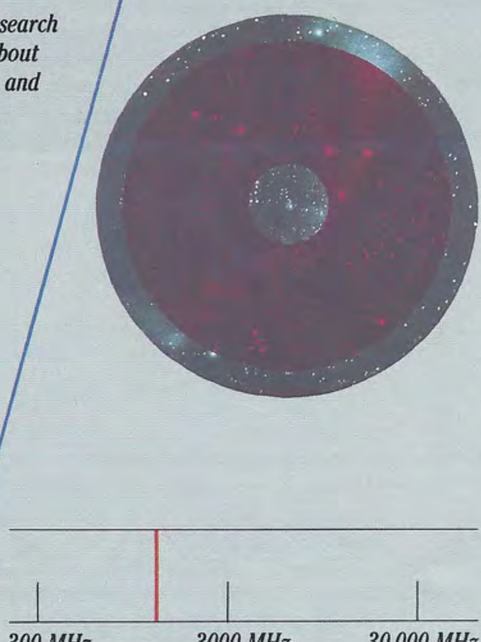
DAY 1:
The Oak Ridge radio telescope points toward the sky near the horizon (30 degrees south of the celestial equator). The telescope is stationary, but in 24 hours it scans a band ½ degree wide (the red circle) as the day and night skies wheel overhead. Within this circle, the receiver monitors a band of many contiguous frequencies simultaneously, centered on the 1420 megahertz emission of hydrogen (the red line on the spectrum chart indicates all 128,000 frequencies). The natural radio noise in the sky is relatively low in this region, so a technical civilization might choose to broadcast near this frequency of hydrogen.



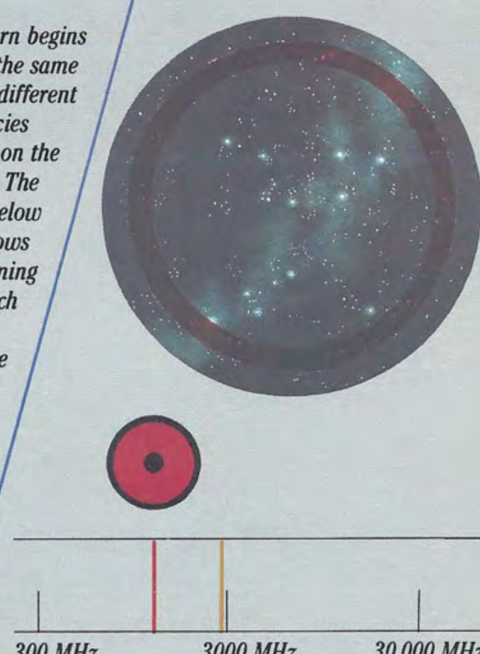
DAY 60:
The search moves up toward the North Star (center of illustration), sweeping out a circle ½ degree wide each day as the telescope is slightly elevated. If we are very lucky, we could detect a signal from another world (white pulse).



DAY 180:
After about six months, the search reaches 60 degrees north (about the level of the Big Dipper), and has covered about ⅔ of the northern sky.



DAY 210:
The search pattern begins again, covering the same area of sky at a different band of frequencies (the orange line on the spectrum chart). The small diagram below the star map allows us to keep a running score of the search by showing the frequencies we've already covered. Note that even 128,000 frequencies are just a thin line on the whole microwave spectrum.



Prepared by
Jon Lomberg and
Thomas R. McDonough

News & Reviews

by Clark R. Chapman

During those wonderful Jupiter-encounter weeks in 1979, when the two *Voyager* spacecraft were zipping past Jupiter, the spacecrafts' camera systems opened new vistas on four new worlds: Io, Europa, Ganymede and Callisto. As the *Voyager* imaging team of scientists struggled to meet deadlines for press conferences and journal publications, they assembled interpretations of the geological behavior of these bodies that have spread out across the world. The large press corps attending the JPL encounters reported the *Voyager* scientists' instant interpretations, then turned to writing books and magazine articles summarizing the project's results. Textbook authors entered stop-press paragraphs about Jupiter's moons in the latest editions of their books, so the early ideas streamed into the minds of thousands of college science students.

Ganymede and Callisto: A 1983 Perspective

Scientific research is not completed in a week or a month, or even a year. The vast amount of *Voyager* data, coupled with the low funding levels for post-encounter analysis, means that *Voyager*-based interpretations of the geological and geophysical behavior of these remarkable worlds will continue to develop for years, until the *Galileo* orbiter begins its 20-month study in 1988.

To someone with a passing acquaintance with the encounter-period interpretations of Ganymede's remarkable topography, Steven Squyres' article in the January/February, 1983 issue of *American Scientist* is must-reading and will prove to be a real eye-opener about how scientific ideas progress. Squyres treats the same features discovered during the first *Voyager* fly-by—the dark and light topography, the craters, the grooves, the evidence for a little bit of faulting, and so on. The intervening years of research have sharpened photogeologists' study of the pictures, however, and have led to more fully developed theoretical interpretations about processes that occurred on and within Ganymede during its earlier history.

It is not really that the early ideas have been found to be *wrong*; they merely seem incomplete and a bit tangential to what Steven Squyres now reports that his colleagues are thinking. Although the grooves are mostly confined to the brighter parts of Ganymede, the existence of an occasional groove within the darker terrain has profound implications. Further consideration of water-ice and its polymorphs (different crystalline structures that exist at different temperatures and pressures: remember Kurt Vonnegut's fictional ice nine) suggests how a Ganymede composed of ices and rocks might have evolved geophysically into the world revealed to us by *Voyager*. The widespread evidence for crustal expansion, deduced from careful measurements of the *Voyager* pictures, now falls naturally into place as the inevitable outcome of the segregation of Ganymede's rocks into its interior and the ices into the lower-pressure regions of its upper mantle. Squyres even believes that the spacings of the grooves on Ganymede might tell us something about the internal profile of heat within Ganymede at a critical early stage in its evolution.

A Post-Viking View of Mars

Research has been continuing, as well, about our reddish neighboring planet, Mars. Michael Carr of the United States Geological Survey led the orbiter camera team on the *Viking* mission in the mid-to-late 1970s. His beautiful and excellent book, *The Surface of Mars*, (offered through The Planetary Society, see book order insert) presents a fascinating summary of what we have learned after years of post-*Viking* data analysis. But if you want a shorter, more succinct treatment of the same topic by the same man—who has one of the broadest perspectives about Mars of anyone alive—I suggest you read the feature article in the January/February, 1983 issue of *Mercury*, published by the Astronomical Society of the Pacific.

In this short but profusely illustrated article, Carr cannot get into all the subtleties and complications that surround the origin of the remarkable channels and river valley systems on Mars. Still, the *Viking* picture of the fault which marks the origin of the immense Mangala Vallis channel is worth the proverbial thousand words and more; it supports Carr's thesis that the floodwaters were released from the interior of Mars when the usually impervious layer of permafrost was punctured by an impact or, as in the case of Mangala Vallis, by a sudden episode of crustal faulting.

As in his book, Carr tells a convincing story about why Mars is so different from our own planet. Paradoxically, Mars retains surface features that are both very young and very old. This small planet, which is clearly less geologically active than Earth, nevertheless has landforms on a scale that vastly exceeds the scale of analogous features on our world. Carr suggests that this is the natural outcome of two fundamental differences between Mars and the Earth. First, Mars by-and-large lacks the large-scale crustal dynamics represented on the Earth by plate tectonics and continental drift. Second, because its water is usually frozen and its atmosphere is thin, erosion on Mars is incapable of erasing many of the ever-growing landforms created on its surface.

A Venus Mission is Born

This summer a new mission is wending its way through the labyrinthine parliamentary processes of Congress. After years of dashed hopes about a Venus Orbiting Imaging Radar (VOIR) mission, JPL engineers have reconstructed a much cheaper version called the Venus Radar Mapper (VRM). The administration has proposed the mission in the fiscal year 1984 NASA budget and, as of this writing, Congress appears to be treating it favorably.

Writing in the April, 1983 issue of *Astronomy*, JPL scientist and engineer Warren James describes how the VRM mission was created from the conceptual pieces of the VOIR mission. More to the point, much of the new mission will use engineering and hardware concepts already employed in other existing missions, like *Galileo*. Thus the Venus Radar Mapper is true to the spirit of the planetary mission program being advocated by the Solar System Exploration Committee (an advisory group to NASA), which will rely as much as possible on commonality between different spacecraft and "inheritance" from previous missions. James' article describes the geophysical implications of the impending Venus mission and provides rare insight into the engineering considerations that help to create a sound spacecraft mission.

Clark R. Chapman of the Planetary Science Institute in Tucson, Arizona, is a member of the imaging science team on Galileo.

Society Notes

by Carol Buck

One of the goals of The Planetary Society is to educate and inform its members and the general public about our solar system and space exploration. We do this through *The Planetary Report* and, more personally, through public events. The methods that we use for this can vary from a small library display to a large event lasting for several days. The Society has sponsored, cosponsored or participated in several such events within the last few months.

Our December, 1982 event, the Washington, D.C. commemorations of *Mariner 2*'s rendezvous with Venus, marked the 20th anniversary of interplanetary flight and was the largest event we have sponsored since Planetfest '81.

On the first evening, about 350 Society members and Washington dignitaries attended a reception held at the Smithsonian Institution's Air and Space Museum. Our members met the people who sent *Mariner 2* to Venus, as well as leaders of today's space program, including James Beggs, Administrator of NASA; Harrison Schmitt, then-Senator from New Mexico in charge of the Senate Subcommittee on Science, Technology and Space; and former NASA Administrator James Webb. A film from the Jet Propulsion Laboratory documenting the *Mariner 2* project, produced especially for this occasion, was a highlight of the evening.

The main event was the symposium, where Drs. Isaac Asimov, Carl Sagan and Tomas Gombosi addressed approximately 850 people. Dr. Gombosi, a Hungarian scientist on the Soviet mission to Halley's Comet, spoke of the value of international cooperation in planetary exploration, citing contributions by Americans and Soviets to the Halley's Comet missions of the European Space Agency and the Soviet international mission (VEGA). He also presented a film which was specially prepared by the Hungarian space agency for The Planetary Society, documenting the building of the cameras for VEGA. Dr. Asimov, experienced both as a scientist and as a writer of science fiction, reflected upon some of the problems encountered when newly-discovered science fact conflicts with what has been written in highly popular science fiction. Dr. Sagan reviewed what we have learned from the exploration of Venus and discussed several pre-*Mariner* theories, often based on inaccurate data, some of which "proved" that life could exist on Venus. These theories were later revised in the light of information from the American and Soviet probes that flew by and landed on that inhospitable planet. A banquet climaxed the commemoration, attended by about 300 Society members and guests from Washington.

Other events, although not nearly as large as the Washington commemoration, have been just as important in keeping our members and the public informed.

Dr. Friedman recently lectured at the Flandrau Planetarium in Tucson, Arizona, a city with a high concentration of Society members. He spoke about the continuing exploration of Venus and Mars, and provided details of the proposed Venus Radar Mapper mission.

In Houston, Texas, Society members joined with planetary scientists at the 14th Lunar and Planetary Science Conference at the Johnson Space Center for a panel discussion on "Prospects for Planetary Exploration."

In Chicago, Dr. Richard Terrile of JPL spoke at the Field Museum of Natural History on the *Voyager* missions to the outer solar system and brought his audience up to date on the latest findings from these missions.

The initiation of Project Sentinel, Professor Paul Horowitz' SETI project using his "Suitcase SETI" receiver with Harvard's Oak Ridge Radio Telescope, received more media attention than any other Society event. This four-year project is now under way, thanks to the donations from many members of The Planetary Society. The three major television networks, and many other television and radio stations, newspapers and magazines, covered the press conference and dedication ceremonies, including a Planetary Society symposium at Harvard University where Drs. Sagan and Horowitz spoke to a capacity crowd.

In New Britain, Connecticut, the second annual Spacefest was held May 6–8 at Central Connecticut State University. This year we provided a display and cosponsored a lecture, reminiscences of *Voyager*, by NASA scientist Dr. Jay Bergstrahl. In Los Angeles, the Futureworld Expo '83 at the Los Angeles Convention Center, held May 5–8, was the temporary home of the Planetary Society audiovisual show, designed by artist Jon Lomberg. Jon worked for two months on this ambitious project, which will be the cornerstone of future Society events, exhibits and displays around the country.

On May 31, at the annual meeting of the American Association for the Advancement of Science to be held in Detroit, the Planetary Society is sponsoring a coffee and donut reception for its members. A symposium, "Searching for Our Analogs in the Universe," will be held later that day.

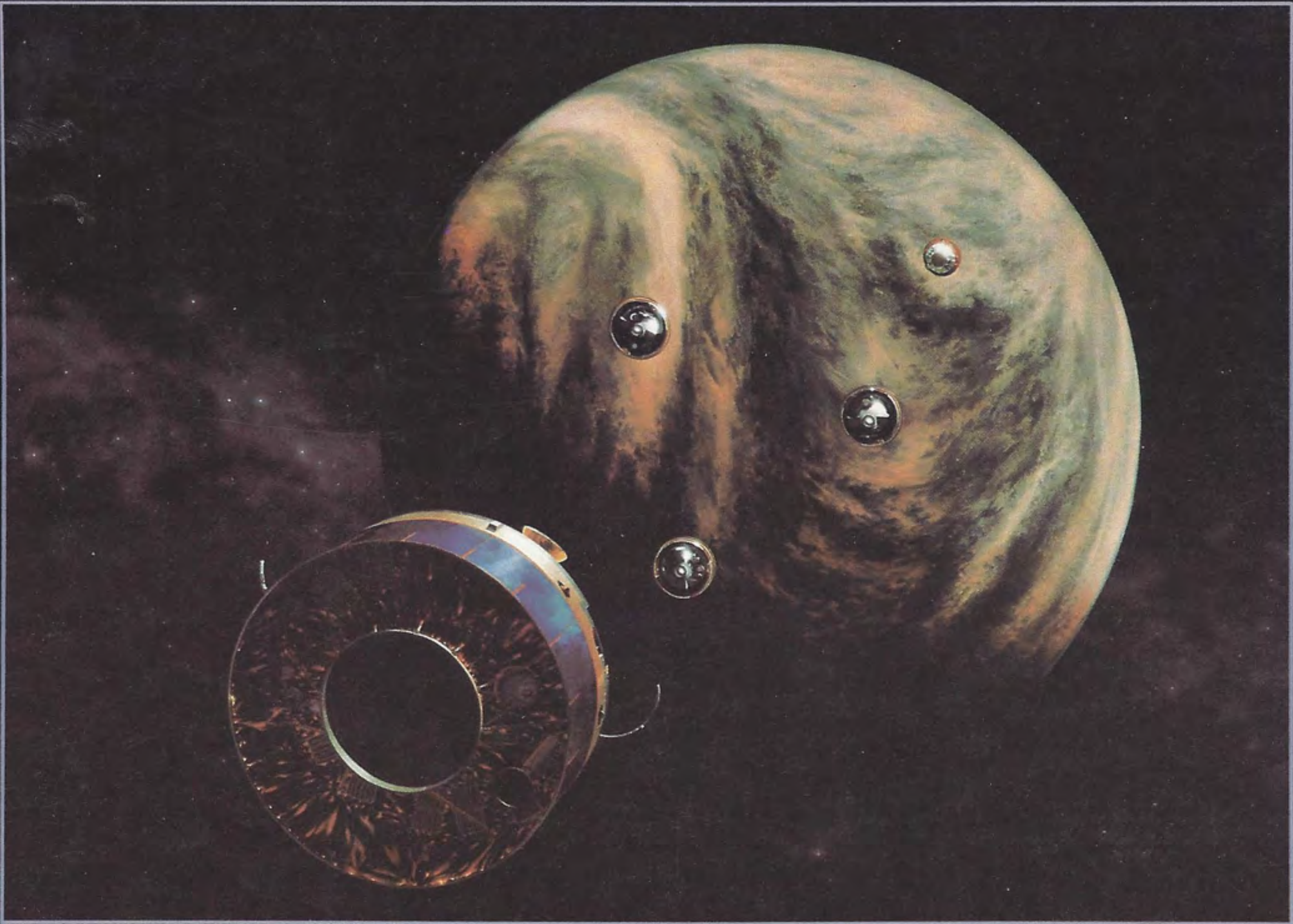
I would like to thank many of our volunteers, who have devoted a great deal of their time to helping the Society organize successful events around the United States: Daniel Cwiertniewicz in Detroit, Teinya Prusinski and Linda Low in Chicago, Jackie DeLarue in Washington, D.C., Lonny Baker in Tucson, Doreen Page in Connecticut, and all those who have helped by arranging benefits for or contributing to Society projects and who have helped in other ways.

Carol Buck is the Events Coordinator for The Planetary Society. A devoted volunteer, she has coordinated local events and provided Society display material and information to members. We appreciate her help very much.— L.D.F.

Planetary Society Information Lines: From east of the Mississippi, call (213) 793-4328; from west of the Mississippi, call (213) 793-4294.

New Advisor Appointed

Dr. Cornelis de Jager has joined the Planetary Society's Board of Advisors. He is the president of COSPAR, the Committee on Space Research of the International Council of Scientific Unions. Dr. de Jager is known throughout the scientific world for his activities in promoting international exchanges and meetings and for editing publications such as *Space Science Reviews*. He is Professor of Astrophysics and Space Research at the University of Utrecht and also is active as a professor in the Free University of Brussels. His main research interests are solar and stellar atmospheres, flares and the acceleration of stellar winds. He has been General Secretary of the International Astronomical Union, President of the Netherlands Astronomical Society, and is a member of the Royal Astronomical Society, London, and the Royal Academies of Arts and Sciences in Amsterdam and Brussels. Dr. de Jager's distinguished career epitomizes the vitality and breadth of twentieth-century European science and space exploration, and we are honored to welcome him as an Advisor.



Early in December, 1978, two Pioneer spacecraft arrived at Venus. One craft launched four probes into the planet's dense and stifling atmosphere, while the other went into orbit and began transmitting data back to Earth. The Pioneer Venus project was the United States' most extensive study of that planet.

Paul Hudson is a show designer with Walt Disney Productions. He also freelances for NASA, JPL and aerospace companies. Mr. Hudson lives with his wife and two children in Montrose, California.

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