EIR Science & Technology

Planetary exploration celebrates 25th year

Though planned missions to Venus, Mars, and Jupiter are years behind schedule, scientists met last December to celebrate the first quarter century of planetary exploration. By Marsha Freeman

The tiny Mariner II U.S. spacecraft arrived at Venus on Dec. 14, 1962, twenty-five years ago, taking the first close-up photographs of this strange new world. Over the following two decades, nearly the entire span of our Solar System has been visited by spacecraft, sent primarily from the United States. In 1989, Voyager 2 will encounter Neptune—the last regular planet in our system.

There has been no field of science so changed in so short a span of time, as planetary exploration. Entirely new fields, such as comparative planetology, emerged as similarities and differences between Earth and her neighbors were revealed by the "eyes and ears" of the planetary voyagers.

U.S. craft, historically prepared and sent in pairs, allowed scientists to use the initial discoveries of the first encounter to more precisely target and aim the second. Preparing two craft also allowed for the possibility that launch vehicle and other failures might occur. For years scientists harvested the bonanza of data sent via telemetry from the spacecraft to Earth, and spent years evaluating and analyzing the information.

Warmly held "facts" and assumptions, such as the handful of rings of Saturn, went out the window. Dozens of new moons were added to the giant planets, which began to more and more resemble small solar systems. Hundreds of questions were generated after each visit, and the basis was laid for more detailed exploration, to generate more questions and perhaps some answers.

But the United States lost its ability to sustain a continuous series of new planetary missions in the beginning of the 1970s, when funding for the space program underwent severe cutbacks. Planetary scientists, recognizing that the number of new science program starts was shrinking, tried to pack as much equipment, to reap as much science as possible, into the few remaining missions.

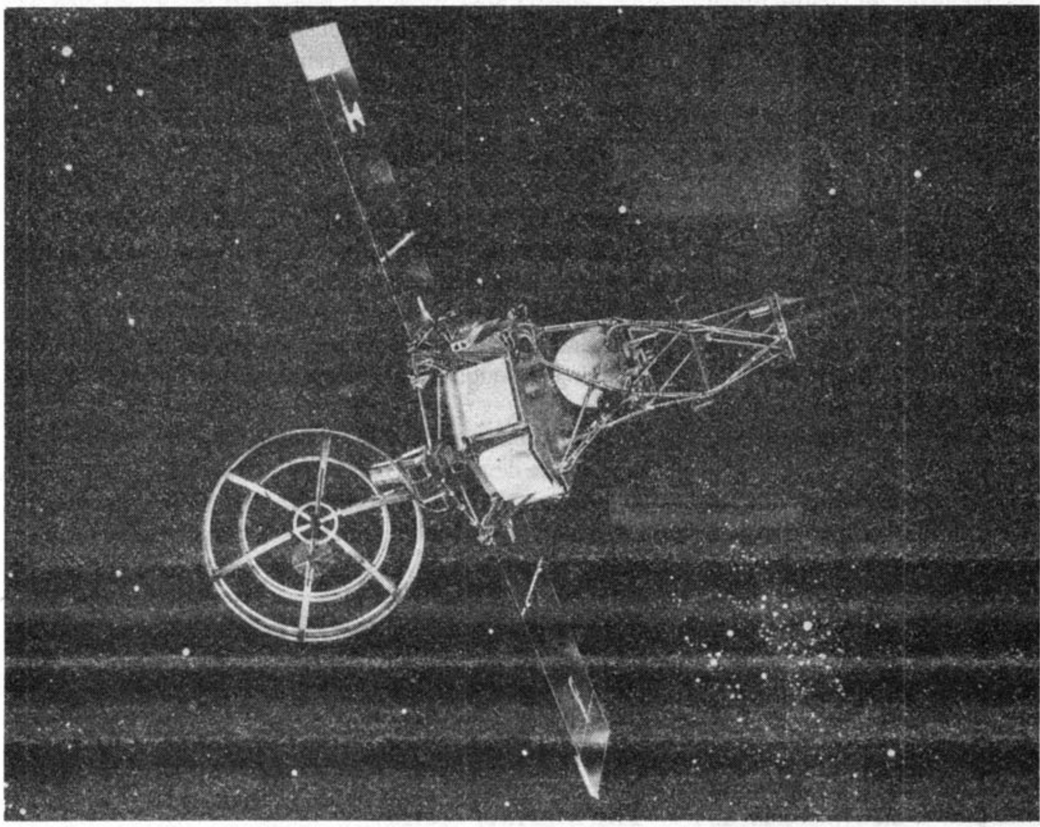
As planetary projects became more and more expensive, fewer and fewer were funded, and those under development were stretched out as budgets became tighter. At the present time, instruments such as the Hubble Space Telescope, and spacecraft such as Galileo to Jupiter and the Mars Observer are ready for launch to continue to revolutionize space science. But because the Space Shuttle is grounded, and expendable rockets for these missions will take years to ready because their production had been shut down, the United States has no launch vehicles to take them into space.

In a presentation at a George Washington University symposium to celebrate 25 years of planetary exploration, Dr. Bruce Murray, who formerly directed the Jet Propulsion Laboratory (JPL) and is currently a professor at the California Institute of Technology, summarized the history and current state of the U.S. planetary programs.

Arguing against the straw man put up by some scientists, that the manned NASA programs "steal" support from science, Murray stated that the national commitment to the Apollo program of the 1960s, "allowed all the exploratory programs" to go forward, because Apollo was a "pull" on all the space technology.

Murray explained that the current trip of Voyager 2 to Neptune is an example of how the U.S. stripped down its planetary programs. It was the first mission where only one spacecraft will complete the mission, as Voyager 1 was not on an energetic enough trajectory from Earth to continue on to Uranus and Neptune.

In order that the audience at the symposium would appreciate the precision with which these complex missions have



NASA

Artist's sketch of the Marine II spacecraft on its way to Venus. Mariner II arrived at Venus on Dec. 14, 1962. It made infrared and microwave measurements of the planet, and sent this data over 36 million miles, back to Earth.

to be done, and the reason that redundancy of a second spacecraft is wise, Murray recounted how the Titan II rocket that launched one of the Voyagers did not fire its engines long enough to put the spaceraft on the correct trajectory. But the Centaur upper stage had been automatically programmed to compensate if something went wrong with the first stage, and burned its engines longer. The Centaur, Murray proudly reported, still had four seconds of fuel to spare when it had finished setting Voyager on its billion-mile, multi-year course.

Today there are planetary spacecraft ready to be launched, but no vehicles to take them, Murray said, because the decision was made in the early 1970s that the Space Shuttle would be the national launch vehicle. The planetary program became dependent upon a manned space system.

Since 1979, the Shuttle payload schedule has lost one year each year, delaying the launch of all of the science missions. The "failure" of the Shuttle, Murray stated, was unrealistic expectations. "It is not possible to make the Shuttle 'safe.' It should be used for things worth risking human life for," he stressed.

The Soviets, he said, use the same launch vehicle (the Proton) for manned and unmanned missions. It is also the case that they have used the Proton for over 25 years. Since the launch vehicle is not connected to the particular mission, Murray stressed, unmanned science missions are not held up because of problems in the manned program.

As current JPL Director Dr. Lew Allen said in a later presentation at the symposium, "Voyager is now in the ninth year of its three-year mission." The scientists who planned the missions, and the engineers who made them possible, have provided the world with a completely new view of the Earth and the rest of the bodies that make up the Solar System. This is no time to halt planetary exploration.

How was the Solar System created?

In an unusually serious and thoughtful speech, Carl Sagan presented a thumbnail sketch of the major discoveries of the 25 years of *in situ* planetary exploration at the anniversary symposium.
Solar System explorer.

Sagan said that the 1962 Mariner II mission to Venus made a fundamental discovery. There was an hypothesis at the time that there was a solar wind, or continuous flow of high-energy particles and radiation from the Sun. But the evidence that existed was from observed concentrations of matter in the tail of comets, that are accelerated as they travel near the Sun, through the Solar System.

Mariner II made the first direct measurement of the solar wind; Mariner II used its radio telescope to look at the radiation near Venus, which led to the discovery that the surface was very hot. Mariner II, said Sagan, demonstrated that it was possible "to make fundamental discoveries from space."

Mariner II did not have any cameras on board, which Sagan said was due to the fact that people thought that they would produce too much "PR" and not enough science.

But there are many remaining fundamental questions in space science, some of which Sagan summarized:

Where do meteorites come from? They may come from the asteroid belt, or from the Moon, or Mars. How is interplanetary material transported? Is it possible that debris from meteorite impacts on Mars have reached the Earth?

The E ring of Saturn, which is made of tiny 1-micron (a billionth of a meter) particles which are scattered by the solar wind, is thought to be a recent ring. Could the material come from debris from the moon Enceladus? Why are there no rings around the (inner) terrestrial planets? Are the rings ephemeral? Why does Neptune apparently have only ring arcs, and not complete rings?

How much interstellar organic matter is there? What are the origins of organic matter in the atmospheres of Titan and Jupiter, the asteroids, comets, meteorites? Why isn't there more on Mars?

The ultimate question, Sagan said, is, how was the Solar System created? The key, he stated, is to find other solar systems, which should give us more insight into our own.

The first planetary program

Space scientist Al Hibbs, who has spent 36 years at the Jet Propulsion Laboratory, explained to the symposium attendees that the laboratory began in the late 1930s and was initially operated by the U.S. Army and tested guided missiles. It was in that role that JPL entered the space program in the period of the International Geophysical Year, in 1957. "Many of you remember that the IGY was actually 18 months long, which is a comment on the way geophysicists keep time," Hibbs commented.

The IGY was the occasion for sending satellites into orbit around the Earth. The joke at that time, Hibbs related, was that there were four budding space programs in the world: the Soviet program, the U.S. Army program, the U.S. Navy program, and the U.S. Air Force program.

"But the decision was finally made to go with the Navy Vanguard program, and in the latter part of 1957, there were unfortunately some failures in this new launching system. In the meantime, the Army had somewhat surreptitiously gone ahead and developed the Jupiter C, which was the Redstone booster with solid rockets. At that time, the Army was constrained from doing any work on satellites," Hibbs reported.

After the Vanguard failure, Wernher Von Braun's group in Huntsville, Ala., had the Redstone rocket ready to go. "We at JPL had the high-speed rockets and the satellite on top and had that system ready to go. We took the whole system down to Florida, put it together, and got it launched successfully on Jan. 31, 1958 Eastern Time, Feb. 1, Greenwich Time. That was the beginning of JPL's and the United States' entry into the space business.

"Shortly after we at JPL joined NASA, we decided we would get out of the satellite business. We would not go into the manned flight business because it was too big. We decided to go into lunar and planetary exploration," Hibbs recounted.

One of the first things JPL proposed was to get away from spinning spacecraft and to develop three-axis stabilized spacecraft, which had not yet been done in 1958-59. "We knew that in the future we would have to have such things. We felt at that time that it was the only way we could imagine, given the technology of the day, to successfully point cameras and other instruments and aim [them]. It seemed the spinning technique could not handle that demand," Hibbs explained.

Work began on the Ranger program, which was the first program to develop the capability of three-axis stabilization in spacecraft. The goal of the early Ranger program was to crash land on the Moon, with the spacecraft "taking pictures as it went in."

"One of the early Ranger designs was to land a seismometer encased in a balsa wood ball on the Moon, to radio back lunar quakes, if any. Those three Rangers that carried that equipment were all failures, so the seismometer never got to the surface of the Moon. Later, Rangers simply took pictures on their way down," Hibbs said.

The Mariner series

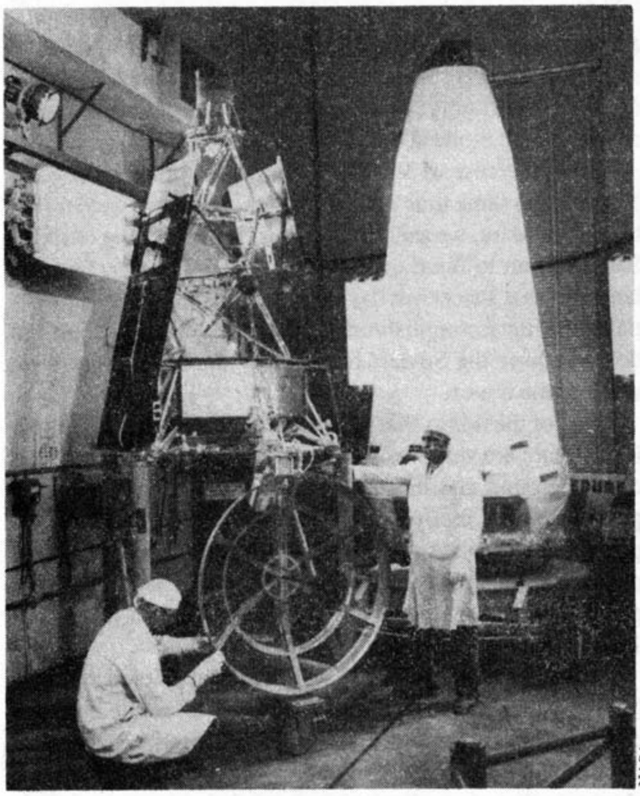
The Ranger technology was expanded to a new series called Mariner, designed to go to the planets. Mariner A was to go to Venus, and Mariner B to Mars. "We intended to use a rocket under development," for the Mariner missions, Hibbs said. "A highly efficient rocket called the Centaur, which used oxygen and hydrogen, and was an upper stage for the Atlas" rocket. "It would have the capability to take between 1,000-1,500 pounds on a trajectory to Mars or Venus."

However, during the summer of 1961 it became quite clear to the scientists at JPL that the Centaur "was not going to meet its development schedule, and would not be available for the launches we had planned in mid-1962. At that time, we suggested to NASA that we could adapt the Ranger spacecraft design for a Venus flight. . . .

"It would weigh less than half the amount we had planned the Mariners for, and would carry fewer instruments, and have a smaller instrument component. The time for this decision was crucial. This was in August of 1961. The launch was to be the following June or July, 10 or 11 months away. . . .

"Mariner 1 suffered a failure of its launching rocket," Hibbs reported, which was why building two of each spacecraft was so important. Mariner 2 got launched in a "wild manner." The Atlas rocket rolled over 360 degrees, or one complete turn, as the rocket was ascending, and as Hibbs said, "it's not supposed to roll one degree, much less 360!"

The Earth sensor, needed to orient the spacecraft, "suddenly went completely out, with the whole spacecraft rolling



Before launch, the small Mariner II spacecraft is subjected to a spin test and check out at Cape Canaveral. The test verified that the measuring instruments would remain steadily pointed while the spacecraft spun, to remain stable.

around in the sky. It rolled around once, and then the Earth sensor was right back on full power—we never understood that one!"

Hibbs described in vivid detail, and through his own experience, the rocky road of the space planetary programs in the early days. Scientists submitted experiments and hardware to the laboratory to be carried into space. Hibbs recounted how, "we received one piece in the early days which was supposed to go on one of the Rangers.

"This was the proverbial 'black box' with a couple or three wires going in for power, and five or six wires going out for the data. We were instructed at JPL, when the box was delivered, not to open it." Naturally, the scientists at JPL opened the experiment, "and we found down in the corner there was a resistor stuck in some compound. We didn't know whether it was supposed to be part of the circuit or was an accident!

"But the worst thing was little blobs of solder just sitting there in the can. Of course, in space there is no gravity—things tend to float around, and blobs of solder tend to float around, too, and cause short circuits." These, plus a number of other problems, "were so awful that we did not try to clean up this box. We went back [to the scientist] with it and showed him the box, and he was as dumbfounded as we were.

"We checked in to how it was built, and it was built by having a big wiring diagram on the wall, and graduate students would come in, in their spare time, and hook together various parts, and then check it off with a red pencil! We got his wiring diagram and the rest of his specs, and we built the instrument at JPL," Hibbs said.

Procedures have become quite a bit more formalized since those early days, Hibbs reported. Now thousands of scientists respond to announcements of opportunity from NASA, for missions being planned, and have the chance to design an experiment and compete with their peers.

But the planetary programs of the United States were to have a rocky road, over the two decades to come. Dr. John Naugle, formerly the chief scientist at NASA, recounted the painful decisions that had to be made in the planetary programs of the 1960s as the budgets contracted. Dr. Naugle's history has some important lessons for today, considering the near 50% cut the Congress has recently made in the space station.

Voyager and Viking

The following is excerpted from the address of Dr. John Naugle.

Mariner 2 was a great achievement. It was one of the few times, in those days, that we got something into space before the Soviets.

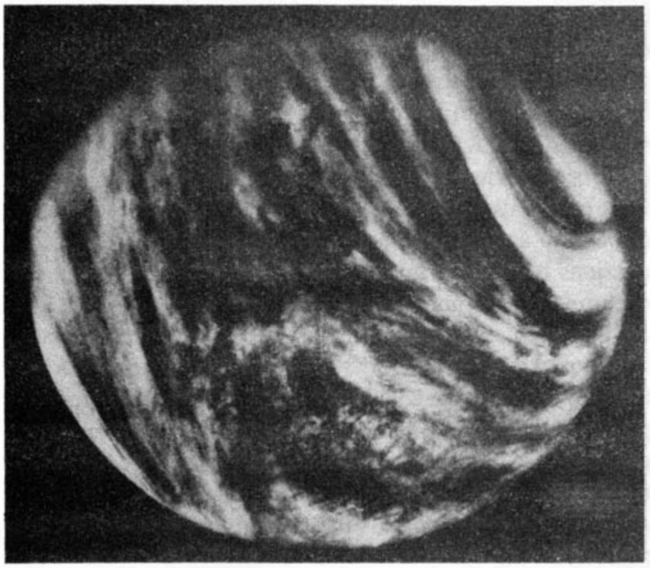
[In the fall of 1967, Naugle became the NASA associate administrator for space science,] and NASA had absolutely no plans for the 1970s or late '60s. JPL was building spacecraft for Mariner 6 and 7, to fly by Mars, but beyond Mariner 6 and 7, we had nothing.

Why was there no planetary program? [NASA Administrator James Webb, who was entrusted by President Kennedy to take mankind to the Moon,] had carefully and deliberately, cancelled it. Why? Because earlier in the summer, for the first time in NASA's history, Congress had cancelled a major NASA project—the big Voyager project, to orbit and land on Mars.

[Since there was later the grand tour Voyager program, which sent two spacecraft to the outer planets, Naugle distinguished between the two, by referring to the Voyager Mars program as "big Voyager."]

NASA had decided that it would use a Saturn V rocket and was going to put two orbiters and two landers on that same Saturn V and launch it all to Mars, to orbit and land, at the 1971 opportunity. It was a $2.5 billion project. In those days, a billion dollars was worth about 7-8 billion of today's dollars, and that was the "going in" price, before any overruns.

[There were a number of reasons why Congress cancelled the project]. One of the things, of course, was that President Johnson had turned his attention from the space program to the Vietnam war. Secondly, Congress was uneasy about the project. It was a lot of money, funding was tight in those



This photo of Venus, composed from invisible ultraviolet light, prominently shows the swirl of clouds at the south pole of the planet. This view was taken from a distance of 450,000 miles by Mariner 10, on Feb. 6, 1974.

days, they turned to the scientists and found them divided, so they cancelled the project.

Webb, irritated with the Congress, decided with his staff, to cancel all plans, and directed us to start over, from scratch. We did.

Eighteen months later, in July 1969, we laid out a program for a new administrator, Tom Paine, which included two Mars orbiters, a Venus/Mercury flyby, a Viking Mars lander, and a grand tour of all of the outer planets.

But in the fall of 1967, that was all ahead of us. For the first time, NASA fired people, and earlier that year, we lost three astronauts in the Apollo fire.

From the experience with big Voyager, there was a limit on the scale of missions we could plan. It was certainly below $2.5 billion. Probably more like $500 million. We also knew that it took about $6-7 million just to get a bare, stabilized spacecraft in the vicinity of a planet.

We also knew some things about the Mars atmosphere: that it was very tenuous, that you couldn't land a payload there with a parachute. You either had to glide in or use a retrorocket. We didn't know if there was life on Mars yet, but we knew we had to avoid carrying any Earthly life there, and we knew that if we landed on Mars, we certainly had to look for life.

We had serious launching problems. NASA had the Atlas Centaur and the Saturn V. The Atlas was too small to land a payload on Mars, and the Saturn V cost too much. We didn't know whether a spacecraft would survive the flight through Jupiter's radiation belts. These were some of the scientific and technical problems we had to worry about.

There was one other thing we had before us all the time, and that was, what were the Russians doing? And the Russians were sending a couple of spacecraft to Venus and Mars at every opportunity, in those days. We were pretty much in a competitive mode at that time.

So in the case of Viking, a big, major program to go to Mars, in the same time period when the Russians were trying to land on Mars, we said to ourselves, if we're going to spend $500 million to three quarters of a billion dollars, then the lander of that spacecraft has to be, or appear to be, a substantial scientific accomplishment. We can't just come along and do something the Soviets had already done. So those were some of the issues.

One of the things that we learned in NASA headquarters, is that there are very few projects that the scientists could get off the ground and make happen, but there's never been a program that's really gone forward that the scientists opposed. The way we solved [the problem of recommending projects the scientists would support, was] that we formed a planetary missions board. It started working in the fall of 1967.

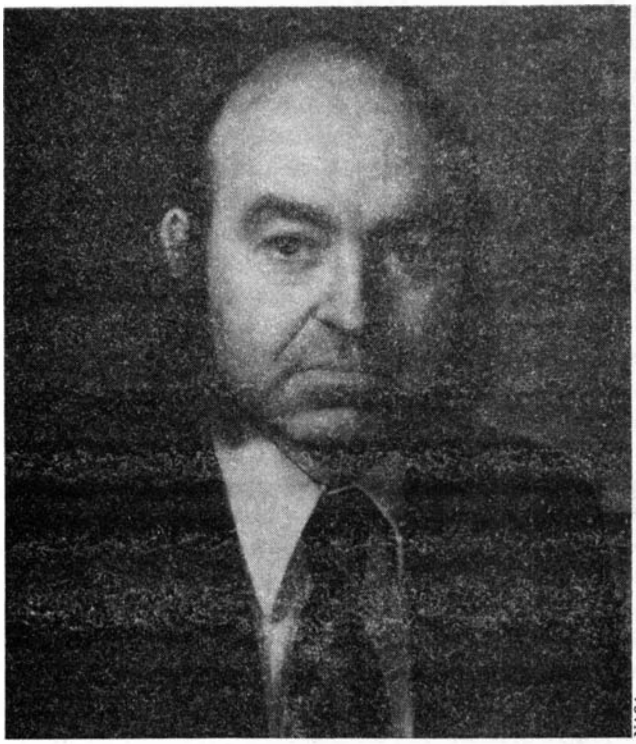
We worked very closely with the Space Science Board [of the National Academy of Sciences] to select the right chairman and right members. We selected a radio astronomer to chair this group, Dr. Pittman. What John brought to the chair was first of all, that he was a good chairman, and that's important. Secondly, he had no particular axe to grind. He had a good job, he had nothing which depended upon the fate of NASA's projects.

Then we deliberately looked around and said, "Who are all the people who have been quarreling in newspapers, who have testified before Congress, about the planetary programs? Let's get all of those people together and let them do their fighting around the conference table, rather than in the media."

One of the issues was focused entirely on Mars. The big Voyager program had been the focus of all of NASA's planetary programs, which was based on that one Saturn V shot to Mars. There were no other plans for orbiters to precede that. The board felt that there should be a Mars orbiter. Homer Newell, God bless him, promptly objected. He said there had to be two orbiters, or none. We happily accepted the second, and it brought back all those nice pictures that we wanted. The first orbiter lies on the floor of the Atlantic Ocean, dumped there by an Atlas Centaur rocket. I always think of those pictures [from the second orbiter] as Homer Newell's pictures.

In that December time period, in that budget, we took the first small step to solve our launch vehicle problems and awarded what was to become Viking. We put some money in to study a type of orbiter/lander. This was a controversial concept inside NASA.

The Titan [rocket] was not a NASA vehicle, it was an Air Force vehicle, and by itself it couldn't land much of a payload on Mars. It really needed a Centaur upper stage. The Centaur


NASA

Dr. John Naugle was the NASA Association Administrator for Space Science in 1967 when the planetary program was temporarily cancelled. He later was Chief Scientist for the space agency.

was a NASA vehicle, built by General Dynamics, a fierce competitor of Martin Marietta, the builder of the Titan. In those days, there was a good deal of competition, also between the Air Force and NASA, so how would you make a marriage like that?

Even though Webb had killed the planetary program, he approved it, and pressed us pretty hard about the orbiter, but we told him everybody seemed to agree on it, [and] he agreed with that. Then we began to discuss with the mission board, various Mars missions based on Titan. During this time, there were some people at JPL who did some work on celestial mechanics and pointed out that we could fly a spaceraft past Venus. It seemed like a good idea, and was cheap, and the board liked it.

We had enough spare Mariner hardw spacecraft. Mariner 6 and 7 had worked well by that time, and the Atlas/Centaur seemed a little more reliable. We then solved some of our [NASA] center workload problem, by turning to the Ames Research Center to study a mission to Jupiter. Ames had handled some small Pioneer spacecraft, but for a long period of time, they had been advocating sending a spacecraft in close to the Sun. Ames's dream was a solar probe, so it seemed eminently logical to ask them to work on a Jupiter mission!

Their task was simplified when some people at TRW came up with an idea for a spin-stabilized spacecraft that would spin with its antenna pointed back at the Earth. The Atlas/Centaur would send the spacecraft to Jupiter to get some data back. There were people on the board that had been arguing that Jupiter was a much more interesting object to study than Mars. So they strongly supported this mission, and we put it in to the plan. In 1968, we solved the other part of the [NASA] center workload problem when Ed Cortright became director of the Langley Research Center.

Ed had led space science for a small stint in the space flight business, and had left that and gone to take over as director of Langley. His heart was really in planetary exploration and he agreed to have that center undertake responsibility for a Titan-based mission to Mars.

He by no means had the bulk of the Center behind him. I didn't realize how much of a schism there was at Langley until I went to pass out the award after the Viking success. It was the poorest-attended ceremony that I was ever at. The Viking team was there, that got the award, and not much else.

The Langley team put together eight possible options for Mars. The smallest, cheapest, was a hard lander—a direct entry hard lander that simply required sending something in to Mars to land. All the way up, the eighth option, the most expensive, was an orbiter, nuclear-powered soft lander that would last 30 days or so, and numbers six and seven were options in between.

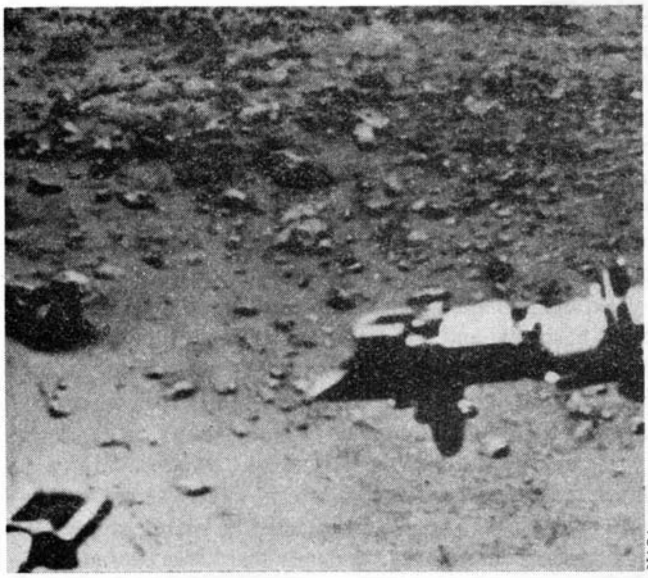
A strange situation developed when you considered those eight options. The farther up the management chain you went, the higher up the option chain you went. The people at Langley and JPL, who had been badly burned by the big Voyager fiasco, were very conservative, and opted for about option five. They didn't think the board would [provide money for more than that], and they didn't want to waste their time on something that wasn't going to go.

Don Hearth, Langley director at that time, was a little more bullish than they were, and he opted for six. I was more bullish—I hadn't been involved in the Voyager fiasco, this was all fun and games for me—so I opted for seven. And, of course, as anyone who knows Tom Paine [would expect], Tom Paine opted for eight, which was what we put in the budget, and was pretty much what we did.

By this time, we were getting pretty far out on a limb with this Titan vehicle, and option eight required a Titan/Centaur. We still had no agreement with the Air Force to use the Titan mated with a Centaur. The election in 1968 helped solve that problem for us.

President Nixon was elected and changed things around, and lo and behold, two old friends wound up in significant positions in the Air Force. Nixon appointed Dr. Robert Seamens the Secretary of the Air Force, and he in turn put Grant Hansen, for former project manager of the Centaur, into the Air Force as undersecretary for launch vehicles.

Seamens, for course, had been associate administrator of



NASA

The Viking landers sent back spectacular views of the rocks and soil of Mars. On the right is the arm of the lander, which had a scooper at its end to pick up and chemically analyze the soil to search for life.

NASA, and Grant Hansen knew the Centaur from General Dynamics, and he was [now] in charge of the Titan programs for the Air Force. So, for the first time, I began to feel that maybe we might be able to marry the Titan to the Centaur, and send a spacecraft to Mars.

Seamens met with Paine and agreed NASA would develop the Titan/Centaur vehicle, and Grant Hansen and I put together a very elaborate plan. You had to marry the Air Force and NASA, and you had to marry Martin Marietta and General Dynamics.

Meanwhile, the people at JPL had continued the work on celestial mechanics and had discovered that in 1976 there was a once-in-every-176-year opportunity to send a spacecraft to Jupiter, Saturn, and Neptune. The board members who felt that the first thing that we should do in planetary exploration was survey all the planets, liked that.

We presented the whole business to Tom Paine in July 1969 using a big screen for projection and the opening theme from 2001. Tom loved it! It wasn't, of course, all that simple. We had to postpone Viking from the best opportunity in 1973. It was a wonderful opportunity in 1973, with Mars close to the Earth. Then there was the following opportunity [1975] which I think was the worst opportunity for the next several decades, in which Mars was on the opposite side of the Sun from the Earth.

We had to postpone Viking from that best opportunity to the worst. [Viking 1 was launched Aug. 20, 1975, and began to orbit Mars on June 20, 1976].

On New Year's Day 1970, early in the morning, I received a call at home that we had budget problems and that I had to come down to NASA headquarters. Between 10 a.m. and 1 p.m. that day, we took $200 million out of NASA's budget, out of the Office of Space Science programs, out of Viking. The missions board became incensed when we proceeded with Viking when the budget was tight, and they threatened to quit one dark and stormy night up in Boston.

They were afraid that if we started this flight, it would eat everything up in the planetary programs, and in the rest of the space science programs. We wouldn't be able to do the Pioneers, we wouldn't be able to do the grand tour [of the Solar System, Voyager]. Their fear was generally groundless. That's a good thing, because had they been right, I wouldn't be here, and nobody would be here, describing what we did.

I hope I have given you a picture of a planning process based on a mixture of compromise, opportunism, and dogged persistence, and some very clever ideas. Are there any generic ideas that might apply to today's problems?

In hindsight, Webb's decision to abolish the planetary programs was sound. There was a mess at the time, and that decision cleared the air and got everyone's attention, and put people to work together to resolve the issues, rather than stand fast for their principles. We started small, and built up the program, mission by mission.

What's different today? Several things. Planetary exploration is different. Nothing but simple flybys had been to the planets in the '60s when we were putting this program together. Today we have watched [parts of Mars] rise out of the dust clouds, and studied Jupiter's red spot, and Saturn's rings. The intense competitiveness we felt toward the Russians would be difficult, if not impossible, to recover.

I think America and Americans are different now than they were in 1967. I do not know how you can arouse the same broad public concern that [existed] among Americans as a result of those years' Sputniks, and Gagarin's flight.

Americans are more interested in career paths, less interested in maintaining U.S. leadership in space science and technology. The Office of Space Science is different. I had control over all elements of the program, and the field centers reported to me. I developed and launched my own launch vehicles. I did not have to spend a lot of time negotiating with another office or another agency for my transportation.

NASA and NASA people are different. For one thing, on the average they are a good deal older than we were in 1967. At that time, if you were over 40, you were over the hill. Today if you're not over 50, you don't have experience!

Today, people are more dedicated to their career paths and their salaries, than they are to their professions, their institutions, or their particular missions.

Now, we were ambitious, we sought higher positions, and more responsibility; we were not all that altruistic. But we also sought higher positions and more responsibility because we wanted the power to make things happen, the way we wanted them to happen.