'Case for Mars' meeting maps space strategy

Marsha Freeman reports on a conference of space scientists to discuss planning a mission to Mars. It's going to require a change in White House policy to get there.

On Aug. 17, NASA released a 63-page report, "Leadership and America's Future in Space," written by a committee headed by astronaut Sally Ride. The report makes the bleak observation that the United States is falling behind the Soviets in the race to explore Mars and in the ability to sustain long-duration, manned space flight.

The Ride committee recommends what might be described as a cautious, though systematic approach to the problem. The United States, they say, should follow a strategy of "evolution and natural progression," rather than repeat the Apollo experience, of a crash program which did not create the permanent infrastructure to continue space exploration. The Ride committee quotes from, and generally supports, the recommendations of the National Commission on Space report, for a manned return to the Moon, before attempting the Mars mission, throwing cold water on the current push from Carl Sagan and his supporters, for a politically motivated space spectacular to go to Mars.

The Ride report's main failing is its lack of a longer-term vision for the space program, in the form of a specific timetable for colonizing Mars, and its willingness to accept as a permanent "given," the constraint of limited budgets. The committee recommended goals that could, by and large, be accomplished by extending today's technology, without pushing out into the frontiers of fusion propulsion, and other technologies that a Mars mission would require.

The committee specifies that there should be a U.S. manned return to the Moon during the year 2000, after an intensive decade of upgraded robotic exploration. This requires a robust Space Shuttle fleet, a heavy-lift launch vehicle, and an operational space station by the mid-1990s, the committee reports. However, trying to propose long-range goals from today's situation, where NASA is not getting enough funding to get the Shuttle flying, build a new launch vehicle, or finish the space station on time, leaves the committee with too many caveats about being able to pay for the program, and not enough specifics on long-range plans.

Rather than worrying about how much programs will cost, NASA's responsibility is to present to the White House, Congress, and the American people, the goals for space exploration, and the progression of breakthroughs in science and technology needed to meet the milestones.

Both the National Commission on Space and presidential candidate Lyndon LaRouche have demonstrated that a 50-year perspective for moving human civilization to Mars is eminently feasible. While not bowing to the pressure for television space spectaculars, the goal for establishing a human settlement of Mars, in the second decade of the next century, should be set by NASA, as well.

On July 20-22, the third Case for Mars conference was held, attended by more than 200 scientists and engineers committed to planning the manned exploration of Mars. The meeting in Boulder, Colorado brought together many of the top space-planners in the United States to map strategies for future manned missions to Mars.

Many of the scientists and engineers making presentations had been working on Mars mission scenarios since the 1960s, but last year's release of the National Commission on Space report recommending that this nation send the first crew to Mars by 2010, gave a renewed sense of purpose to the conference discussions.

The kind of technologies reviewed at the Case for Mars

The surface of Mars, as photographed by the Viking lander in 1976. Space scientists are demanding a timetable which will allow the first American to set foot there—but the budget-cutters and pseudo-scientific kooks are standing in the way.

conference, which included fusion-powered space propulsion, and even more advanced ideas for matter-antimatter propulsion, give a proper answer to the apparent dilemma, posed by the report released by Sally Ride's NASA committee. Only by rapidly developing frontier technologies can the United States recapture its lead in space, and at the same time create the kind of space infrastructure which can open doors to new technologies.

Such a program will be key to revitalizing the U.S. economy as well. We can confidently expect that the Mars colonization project, properly conceived, will be the kind of test bed for new technologies which will guarantee two to three orders of magnitude increase in the ten-to-one economic payback, which resulted from the Apollo program.

A new Office of Exploration has been established at NASA to recommend to the NASA administrator and the nation what the United States should do in space, into the next millennium. The Ride group report is the first fruit of this.

Speakers at the conference were acutely aware that a competent answer to what America's future in space must be, could not come from within NASA, without a transformation in administration policy. Every conference speaker addressed the necessity for a change in White House space policy. There has as yet been no response from the President to last year's report by the National Commission on Space. As conference speakers stressed, though NASA must make the long-range plans, only the chief executive of the nation can set America on the road to Mars.

Carl Sagan's duplicitous drivel

The day before the Case for Mars conference officially opened, there was a speech by Carl Sagan and a panel discussion, sponsored by the Sagan-led Planetary Society, on why we should go to Mars. Sagan himself, playing to the prejudices and ignorance of his young college audience, made his most outrageous "pitch" yet for a manned U.S. mission to Mars.

Since November 1984, Sagan has been campaigning for a U.S.-Soviet manned Mars mission, on the theme that it would be a step forward to détente with the Soviets. In the past—as in the case of his now-discredited nuclear winter hypothesis—he has shown himself to be dishonest as well as incompetent. His Mars campaign is no exception. He claims that such a mission would have no scientific value and would be 10 times more expensive than unmanned missions, and would take money away from space science. Nevertheless, according to Sagan, it is needed to improve U.S.-Soviet political relations. The Mars mission would, he claims, have the two nuclear superpowers "cooperating in space" as opposed to competing in "militarizing" space. It is his way of getting rid of the U.S. (but certainly not the Soviet) Strategic Defense Initiative.

Sagan tried to argue that economic "spin-offs" from the Apollo program were a fiction, since they could have been replaced with specific programs to produce the new technologies. For example, he driveled, the United States could have had a "Strategic Pacemaker Initiative" and gotten the same

heart pacemaker technology we got from the Apollo program, without spending $20 billion!

He admitted that he conceived of a manned Mars mission as a way to "ease conversion away from military procurements" in the aerospace industry, by the "start-up of a grand, long-term, high-technology endeavor." "If you wave a trillion dollars in front of the aerospace industry," Sagan stated, "You get a funding frenzy . . . a powerful juggernaut."

The National Commission on Space, the NASA Office of Exploration, and every serious space-planner for years, have all proposed that the United States return to the Moon, to develop industry there, and learn how to move human civilization off the Earth, before going to Mars.

Sagan, on the other hand, revealed his duplicity by counterposing a Mars mission to the establishement of a permanent lunar base. His argument went as follows: "What's wrong with a lunar base? It is scientifically much duller than Mars, could be a detour or a trap, could take up resources and indefinitely postpone a Mars mission. . . . It doesn't have enough excitement to maintain interest in a long-term program." For all of the warnings of experienced space hands that another "Apollo-style" single-shot effort, which built no lasting infrastructure, would be a dead end, Sagan is proposing an international publicity stunt, which is not the same thing as a space program.

The day before this speech and panel discussion, Sagan had led a few dozen U.S. scientists in Boulder in live, direct satellite broadcast discussions with a similar number of Soviet scientists in Moscow, on joint Mars missions. This "space bridge," as it was described, lasted for four hours, and will be turned into a one-hour Public Broadcasting System program this fall.

In response to Sagan's performance, Lyndon LaRouche wrote, in an article titled, "Carl Sagan Peddles Soviet Line at U.S. Space Conference": "If Dr. Carl Sagan, one of the *New York Times*'s more admired anti-science figures, had been around at the time the wheel was invented, Carl would have led a lobby to demand either that the wheel be banned altogether, or that only square wheels be allowed. Carl would have insisted: a) that it shouldn't be built, b) that it wouldn't work, anyway, c) society would never gain any pay-back from its use, d) that it was potentially militaristic, because someone might use it to build war-chariots, and, probably also, e) that, as a friend to labor, he must oppose it, because it was labor-saving and would take away jobs from load-draggers."

LaRouche points out that "one of Carl's leading points of argument . . . was that mankind would not get a significant pay-back from investment in a Mars colonization program. This is the same argument the Soviet propaganda machine concocted against the U.S. SDI program." LaRouche proceeds to outline the origin of this argument, and demonstrates how "science works in our economy" and has done so, throughout history.

Though Sagan got a rousing round of applause from the college students attending his presentation, the scientists and engineers attending the Case for Mars conference sessions were not impressed with his theatrics, and he was effectively rebutted by Dr. Thomas Paine, who was the NASA administrator in 1969 when the Apollo 11 crew landed on the Moon. Recently Paine chaired the National Commission on Space.

No limits to growth

Paine stated that the purpose of sending people to Mars is "the limitless growth potential of mankind . . . that will eliminate the malthusian limits to human aspirations." There is no question, Paine continued, "that there is great national pride and leadership in participating in such programs that are in the forefront of man's aspirations. I think that the leadership of far-seeing countries will wish to use some of the affluence they develop from past applications of science and technology, to bring the best to this greatest of high-technology human adventures. I think that very few leaders of nations in the future world would not want to have their nation participate."

"In addition to the chauvinistic, perhaps nationalistic feeling," Paine stated, "there are a few humanistic, ideological, even religious reasons. The basic desire to preserve life, to expand and transmit deeply treasured human beliefs to posterity, to open up our own past cultural heritage to new environs, new civilizations, is one very strong reason for participating."

One of the reasons Americans, in particular, will go to Mars, according to Paine, is that the frontier "offers people a new start. The fact that we are celebrating the 200th anniversary of our Constitution this year, is also a reflection that probably not as much would have been accomplished if the human race had remained in Europe," he said.

What kind of society do we envision on Mars? As opposed to the "pro-space" environmentalists like Gerard O'Neill, who think you can live in space with "low technology," Paine looked into the future and saw that a "Martian civilization . . . a century or two from now will certainly be an intellectually based culture; will be one that is working toward the limitless future of mankind, under very stringent and difficult conditions, but I think, conditions that will also have many advantages."

"They will be free," Paine continued, "of the old world's diseases, ignorance, fears, outworn prejudices, and rivalries, just as our culture in America has been an advance over that of Europe. It will be a technical pilgrim's haven; a chance to build a bold, forward-looking new technology-oriented frontier society."

Looking at the historical and philosophical importance of moving civilization to Mars, Paine remarked, "If we can develop a self-sustaining community on Mars that can live off the land, then we will be demonstrating the first prototype extraterrestrial community"; not a few colonists huddling

together in the cold and the dark, but "a society that is uniquely oriented toward research, development, and exploration."

To locate the current problem of leadership and political will evident today, Paine described how "one of the great disappointments of the 1950s was the failure of the United States to orbit a satellite, when we had it quite within our power to do so. . . . We didn't do it. We were, of course, upstaged by Sputnik, and there was a great deal of feeling that somehow America had failed a little bit in its vision."

America's "technology, its science, had perhaps not been quite as forward looking . . . as might have been. I say that," Paine continued, "because one of the questions that is before our conference, here in the 18th year after Apollo and in the 30th year after Sputnik, is, when will we be ready to explore Mars?" When we are ready, he explained, will depend upon when the technologies are there for this challenging mission.

"There are many new ideas just in the laboratory phase, from using tethers in imaginative ways for moving payloads around . . . new ideas in laser propulsion—a whole host of things, all of which suggest 21st-century technologies for getting ready to move to Mars."

Paine and other members of the National Commission on Space, which was established by the Congress to put forward a long-range plan for the space program, are utterly frustrated by the lack of attention their report has received at the White House. Presidential Science Adviser William Graham is responsible for this blackout. Presumably, Graham wisely realizes that since the only notable thing he did in his short career as acting NASA administrator was allow the launch of the Shuttle Challenger, resulting in the loss of the orbiter and the crew of seven, that perhaps no one is interested in his ideas about the space program.

Current NASA Administrator James Fletcher made a bold presentation at the Case for Mars conference, stepping out ahead of the disorganized White House, and endorsing the Mars mission.

'We should go to Mars'

Dr. Fletcher began his presentation to the scientists, engineers, and mission planners at the conference by stating: "I don't think that the question is whether people will go to Mars—I firmly believe that we should go to Mars, and I am confident that we will go. The question is, when will we be ready?"

"People could very easily be en route to Mars in the early decades or second decade of the next century," he stated. "For that to happen, much needs to be done, in a logical and orderly way. That's why I believe we must begin now to define such a mission, and to define the technologies that will be required for success." Such an upbeat statement on the future of the space program has not been made by a high-level NASA official, since James Beggs was leading the space agency.

On the question of the priority of another lunar mission, he said that many people think that "the best way to Mars is by way of the Moon, and Tom Paine's Commission was no exception. They felt very strongly that there are considerable advantages of going back and establishing a base on the Moon—a permanent base, not just a visit, but a place to live and work, before we tackle the bigger job of going on to the planet Mars."

"It's important to learn to live in a world very different from our own," Fletcher explained, "and the Moon gives use that experience. Second, we could test the machinery for closing the loop [in life support systems]. Third, we could use the Moon as a transportation node; it can be a jumping-off place for anywhere else we want to go in the Solar System, particularly Mars."

"Finally, the experience and importance of the laboratories and habitats on the lunar base—that technology can be transformed to Mars missions, certainly decreasing the risk of Mars missions. Remember, the Moon is only a day and a half away. Mars is a year away. You've got to make sure everything works for an entire year," he summed up.

Dr. Fletcher was followed by one of the small handful of astronauts who opened up the Moon to human exploration, exactly 18 years ago. Buzz Aldrin, the second man to step on to the surface of the Moon, on July 20, 1969, announced

that he, Neil Armstrong, and Mike Collins, the crew of Apollo 11, support a declaration for the human exploration of Mars. Why?

"We believe that the best and most fruitful act[s] in space will include more manned exploration, and pioneering, more pushing out into the unknown areas. . . . I think with strong and forthright leadership, the kind that 25 years ago inspired us to become the first on the Moon . . . we will make the right decisions, and earn the public's unequivocal support," Aldrin stated.

"I think the American people know that space is the future. Space is where some of our children will live. . . . Some groups say we're an instant gratification society, without patience to make a long-term investment. . . . [The American people] know it took almost a decade after Kennedy's challenge to get to the Moon . . . they know that nothing worthwhile happens overnight."

Go with the Russians?

The major thrust of Carl Sagan and the Planetary Society has been to insist that the way to go to Mars is with the Soviet Union. Bruce Murray, Planetary Society spokesman, stated, "either we must compete or collaborate with the Russians" in going to Mars. Somehow competition is now seen as unfeasible, primarily because of the U.S. budget constraints.

Dr. John Logsdon, a George Washington University professor, reminded the participants that international cooperation in space is "political in motivation. Going to Mars will involve a major policy decision. We won't cooperate without *two* major policy decisions."

Michael Michaud, the Department of State representative who negotiated the U.S.-Soviet space agreements in the Carter administration and in the current administration this spring, summed up the realities of joint missions with the Russians. A joint mission, "could delay and hold back Mars development, and hold it hostage to shifting political sands. Only with SDI did this cooperation program emerge" on the part of the Soviets, he stated, and they have counterposed it to the supposed "militarization of space." In other words, this is a strictly political initiative, which should play no role in the planning of the U.S. space program.

It was not difficult to imagine how NASA policymakers and others could get pulled into the maelstrom of hoping the Soviets would chip in part of the funding for Mars missions. The Office of Management and Budget's Jack Fellows made sure the Grim Reaper Gramm-Rudman image was clear in everyone's mind.

"This is not the 1960s," Fellows intoned. "The world's grown up, things cost more. It is not clear to me going to Mars is a national priority. Mars has to compete with the entire space program" budget.

But John Aaron, newly appointed head of the NASA Office of Exploration set up by Dr. Sally Ride, stated that the purpose of the Space 1995 report released by his office is to "recapture the high ground of preeminence in space." Just so the government knows exactly what the "competition" is doing, his office has also commissioned studies on the Soviet space program.

Dr. Nicholas Johnson, a respected analyst of the Soviet program, who works for the Teledyne Brown Company in Colorado Springs, Colorado, presented a picture of the Soviet approach and capabilities that would be required for manned Mars missions.

In general, the Soviets have used current technologies to try to solve complex problems in their space efforts, Johnson reported. They used "the same spacecraft for 10 years for all of their unmanned missions," he stated. Similarly, they introduced the Proton booster in the early 1970s, and still use it to launch their unmanned science spacecraft, with only minor modifications, 15 years later.

After a series of failed Mars missions in the mid-1960s and early 1970s, they turned their attention to an intensive study of the planet Venus. With the launch of their Phobos mission next year, they will introduce a third-generation basic science spacecraft, which Johnson expects they will use to the turn of the century. It has a flexible design which can also be adapted to look at the outer planets past Mars, and perhaps also take their scientific instruments back to the Moon.

Though the instruments the Soviets place on their planetary orbiters and fly-bys are considerably less sohpisticated than comparable U.S. instruments, "they're doing the mis-

sions," and we're not, Johnson emphasized.

Although the Soviets have a nearly constant manned presence at their Mir space station, they have had equipment failures, and even with four modules attached, Mir is still only one-half the size of the 1970s U.S. Skylab space station, Johnson stated, to indicate that a lot of work is still to be done before the Russians can launch a crew to Mars.

Johnson shares the assessment of the Soviet capability generally prevalent among U.S. analysts. These analysts tend to overlook the spin-offs to Soviet technology which will come as a result of their own strategic defense initiative, for example, in the area of radio frequency weapons.

Johnson discussed the fact that the Soviets still need reliable, long-term propulsion technologies, which will safely get cosmonauts to Mars and back. They will also have to develop near-continuous communications links, similar to the Tracking and Data Relay Satellite being deployed by NASA. Without this in-space relay capability, the ground mission control can only communicate with crews a small percentage of the time they are in orbit. When people are being sent several millions of miles away, voice and data communications will be their only contact with the Earth for months.

A third area of needed emphasis, according to Johnson, is the development of on-board data processing, more artificially intelligent automatic systems, minicomputers, and general automation. The Soviets have made some advance in this field in the Mir space station, where the cosmonauts do less mundane station-keeping, and more is done by computer or ground control.

But a Mars mission must be almost entirely autonomous from ground control, because some decisions will have to made immediately, and in many cases, it could take 10 minutes for communications to go back and forth to the spaceship.

A fourth area of work is in power generation and storage. The Soviets have had significant problems in maintaining solar energy storage batteries, Johnson reported. The Soviets have continued an aggressive nuclear power in space program, however.

Redundancy in life-support systems for the crew has not received a high degree of emphasis in the Soviet space program. They will have to "close the loop" in life support, by developing the technology to recycle waste for reuse, since it is too expensive to throw waste overboard and carry along everything you need for the entire trip.

According to Johnson, the Soviets are conducting a "technology assessment program now, collecting data from unmanned missions, and preliminary design will be done in the early 1990s," for a manned Mars flight, in "2000 plus."

The Soviets have planned a series of unmanned missions between 1988 and the end of the next decade. Although it is hard to imagine that they would attempt a manned Mars mission without having gone nearby to the Moon first, they clearly do see it as a goal in the next century.

Precursor missions and strategy

Before the United States can send people to Mars, a number of precursor unmanned missions must be done. Before the first men landed on the Moon, 15 robotic spacecraft explored it from orbit and from the surface. As the Moon is more homogeneous than Mars, it is likely Mars will require more extensive pre-manned exploration.

According to space scientist Bruce Murray, the categories of information needed include:

- Safety for landing. A site must be chosen where there is adequate information about dust, sand, and boulders, and characteristics such as the chemical reactivity of the soil must be known before the materials for landing craft are chosen.
- Environment for mobility. No one we send to Mars will sit inside a spacecraft and look out the windows. In order for crew members to get around by foot and by vehicle, the wind, frost, dust storm and other variables that could affect mobility, must be known.
- Site selection. Criteria must be agreed upon for the selection of one site. This will depend on the relative importance of the exploration of the striking geophysics of Mars, science objectives, etc.
- Materials for long-term exploration. On even the first landing, a scoping study will have to be done, to pinpoint the concentrations of certain materials, which will be prerequisite to sending more people. The most immediate material to find will be water.

Donald Rea, from the Jet Propulsion Laboratory in Pasadena, California presented the program profile for one of the most important, and exciting, precursor missions that NASA is already planning. An automated Mars rover, which

NSIPS/Marsha Freeman

Dr. Thomas Paine, at the Case for Mars Conference in Boulder, Colorado.

would bring back samples of soil, rocks, and dust from Mars would give scientists the benefit of the best laboratories on Earth to analyze the chemical composition and characteristics of the Martian soil, and will add precious data to the debate about the possibility of life on Mars.

Rea reported that the studies at JPL were accelerated this spring, when the Ride committee setting up the Office of Exploration began filling out the requirements for a manned Mars initiative. Conceptual design studies are being done at the NASA Johnson Space Center, JPL, and by Science Applications, Inc. and will be finished by the end of fiscal year 1988.

The timetable the planners are using, is a new start for the rover sample return in the FY93 budget, with a launch in 1988. By the year 2001, the samples would be returned to the Earth.

New mission profiles are also being explored. From the 1948 publication of Wernher von Braun's basic work, *The Mars Project,* until recently, the baseline mission used was chemically propelled rockets, taking off from Earth orbit. The spacecraft are given an initial velocity or push out of orbit, and coast all the way to Mars.

Using this ballistic or unpowered flight profile, depending upon where Mars is relative to the Earth at launch, the trip takes at least 250 days. The spacecraft would travel about 700 million miles, not the 35 million straight-line distance between the two planets, because the planets continue to move around the Sun.

The return trip, in this baseline mission, would take the same amount of time, and the crew would have to spend more than a year on Mars, to wait for the planets to be in the right configuration for the return. It is starting to become accepted thinking, that this nearly three-year-long trip would probably not be safe for the crew, and would make extraordinary demands in food, water, and other consumables that would have to be carried with the crew from Earth.

The permanent solution to this dilemma is to develop propulsion systems that do not travel unpowered through space, but are constantly accelerating. It is also quite likely that the constant artificial gravity produced as a function of the acceleration, would eliminate or at least greatly diminish the deleterious medical effects of long periods in zero gravity.

The best candidate for 21st-century Mars propulsion is thermonuclear fusion power, which produces high-density energy and will allow a constant-acceleration propulsion design.

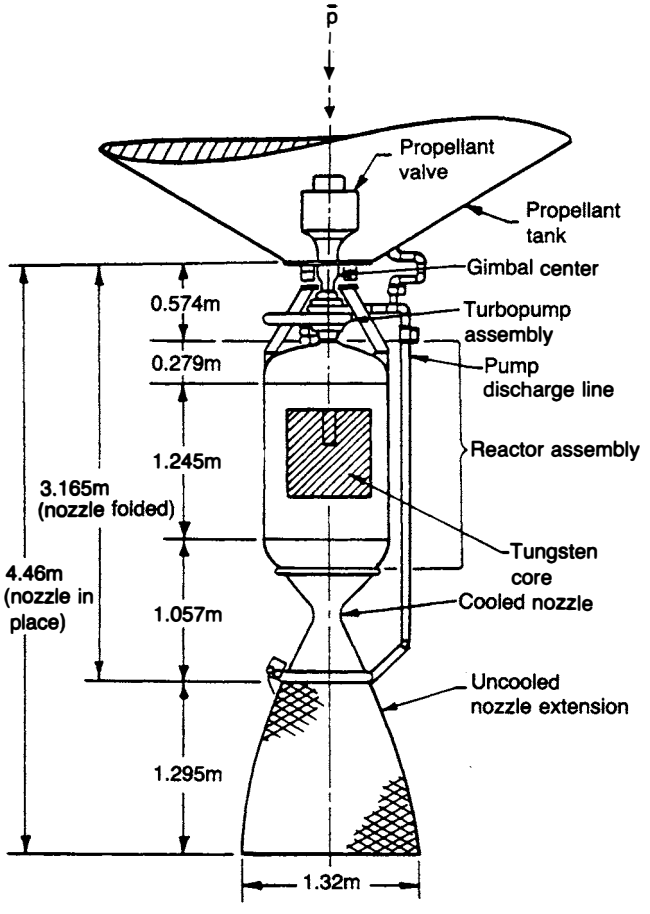
At the Case for Mars conference, John Niehoff from Science Applications, Inc., presented an innovative idea for a "piloted sprint mission." The idea is that the entire trip would take a little more than a year, with a 4-6 week stay at Mars. The propulsion used would be chemical fuel—liquid hydrogen and oxygen—but would impart the crew spacecraft a higher initial velocity or give it a bigger push away from Earth orbit, than the previous mission profiles.

Niehoff explained that his design made use of another, newer concept which received a lot of attention at the conference. Called a "split mission" the idea is to divide the cargo and crew requirements into two different spaceraft. For the "sprint mission" the automated cargo vehicle—which includes the fuel for the return trip, the equipment for the surface exploration, and other materials—would have an initial mass of 60 metric tons in low Earth orbit.

The second vehicle consists of the piloted spacecraft and crew, and has an initial mass of 75 metric tons. The major advantage of the split mission, is that since the time it takes the cargo to arrive is secondary, as long as it arrives before the crew, and therefore, it can use a less energetic mission

FIGURE 1

The Small Nuclear Rocket Engine designed during the NERVA program



The nuclear reactor core has been replaced with a possible configuration of the metal-honeycomb used to convert the antimatter annihilation energy into heat.

Source: S.K. Barowski, *A Comparison of Fusion/Antiproton Propulsion Systems for Interplanetary Travel,* 1987.

profile, and go on a conventional ballistic trajectory.

Niehoff estimated that the split mission would reduce the total launch requirement of material into Earth orbit by half, compared to taking everything on the sprint profile. Using more fuel-efficient nuclear electric propulsion rather than chemical fuels, would reduce that launch requirement by another third.

But it is unlikely that a one-year trip would not have serious medical effects. The only long-term solution to taking people safely and frequently to Mars, however, is to push forward on tomorrow's frontier technologies, and go with the propulsion systems that are needed to go to Mars, and beyond.

Propulsion for the next century

A surprising amount of work is being done on propulsion technologies, spanning those that could be ready by the turn of the century, to some that might take almost another century to develop!

On the nearer-term side, Ryan Haaland, from the Air Force Astronautics Laboratory Nuclear Propulsion program at Edwards Air Force Base, California, reported that the Air Force plans to flight-test and demonstrate a nuclear propulsion system by the year 2001. The mission will be an orbital transfer vehicle (OTV), which is needed to take satellites and other payloads from low to higher Earth orbit.

Haaland stated that by 1989 they expect to complete the design for the system, develop components through to 1992, have a ground demonstration in 1997, and the flight test four years later. They are examining the possibilities for upgrading the 1960s ROVER/NERVA nuclear reactor and propulsion systems, which were canceled in the early 1970s, when the Mars mission was canceled. They are also looking at next-generation nuclear fission technology, such as particle bed reactors, for a more efficient system.

The OTV the Air Force is designing the nuclear propulsion for, will require 300 megawatts of power, and will produce 10-15,000 pounds of thrust. Haaland and his colleagues are on an organizing tour, trying to drum up support inside and outside the military to involve the Air Force, then NASA and the Department of Energy.

A bit further in the future, is fusion propulsion, which *EIR* has covered extensively in the past few issues.

But beyond fusion, and perhaps, into the second half of the next century, are an array of possible propulsion techniques, which if they cannot be used for propulsion, may very well contribute to the multitude of other energy requirements that space colonization will demand. These new technologies are now being thought of in space travel, but are being primarily developed by the SDI program.

These include matter-antimatter systems, though Steve Howe who works on this research at the Los Alamos National Laboratory readily admitted in his conference presentation that we do not know how to produce, store, or use antimatter in needed quantities. **Figure 1** shows a possible design presented by Howe to visualize this far-into-the-future system.

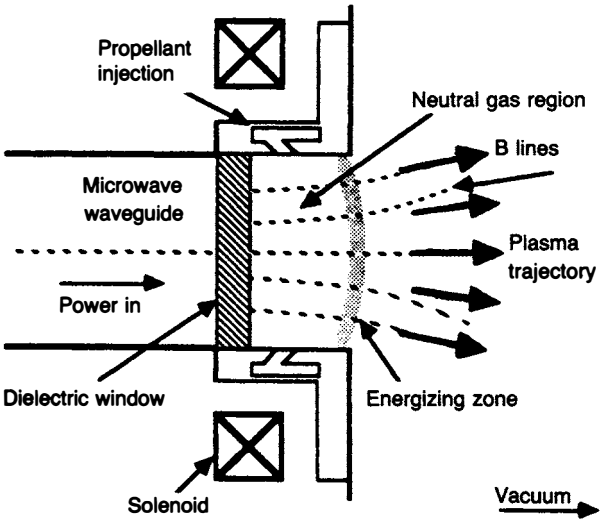
Another researcher from Los Alamos, Bill Porter, described work there on using a plasma to accelerate a particle beam, which could conceivably be a driver for a propulsion system.

Joel Sercel, from the Jet Propulsion Lab, presented a paper on electron-cyclotron-resonance (ECR) plasma acceleration (**Figure 2**). In this design, any power supply can be used to produce microwave energy, which accelerates a tenuous plasma, through the use of magnets. The intensity of the magnetic field surrounding the microwave waveguide is adjusted so the frequency of the motion of the electrons around the magnetic field lines in the plasma, are equal to the frequency of the applied microwave radiation.

According to Sercel, "This frequency matching provides a resonance between the microwave field and the electron-cyclotron motion that enhances microwave-to-plasma coupling." The microwave energy deposited in the electrons accelerates them. This higher-energy plasma could theoretically be used for propulsion, along with any source of microwaves. Though the author suggests that this accelerator could use the microwaves produced by a fusion reaction to accelerate a plasma for propulsion, it is unclear why the fusion plasma would not be directly used.

Only the broadest research program to develop the technologies to go to Mars, will actually get us there, in the next century.

FIGURE 2
Schematic of ECR plasma accelerator



Source: J.C. Sercel, *Electron-Cyclotron Resonance (ECR) Plasma Accelerator*, 1987.