America is back in space: On to the Moon and Mars

It is time to dig up NASA's old plans for lunar and Mars trips, and develop the technologies that will make these steps to space colonization. Marsha Freeman reports.

The recent successful flight of the Space Shuttle *Discovery* has put American back in space, and restored confidence in the world's only reusable space transportation system. Not coincidentally, the day *Discovery* lifted off from Cape Canaveral, the Soviets released the first photos of their as-yet-untested space Shuttle, which, as everyone commented, looks familiar.

Also on the same day that *Discovery* lifted off, representatives from the United States, Japan, Canada, and the European Space Agency, met in Washington, D.C. to finalize their commitment to jointly complete and deploy the next piece of infrastructure needed for space exploration—the space station, which President Reagan has refused to fully fund in the past two years.

The President who assumes office at the beginning of next year, will have to initiate a series of steps in his first 100 days to get the space program back on track, and to keep the commitments made to our international partners and this nation, to move ahead in space exploration.

The next step in any long-range plan—the space station *Freedom*—is now hanging in suspended animation, waiting for the next President to decide its fate. Though it was the "next logical step" after the Space Transportation System (as the Space Shuttle is formally known) began operation, it has been held hostage to the budget mania in Washington. Though each of the major presidential candidates says he "supports" the program, neither one is willing to put a dollar figure on his support.

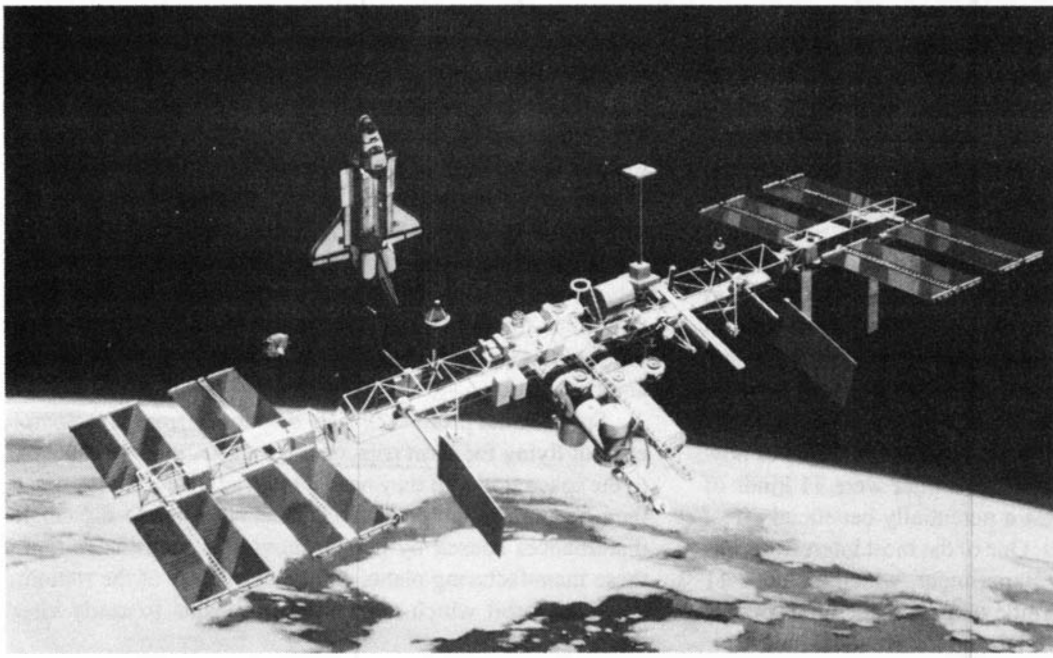
Michael Dukakis, who was "lukewarm" on supporting the space station before the Democratic convention, was lobbied by 14 senators to support the project. So far, Dukakis is on record calling for "new management" for NASA, opposition to the National Aerospace Plane program, opposition to the Strategic Defense Initiative, cooperation in space with the Soviets, and vaguely for support for the Shuttle and station.

In a speech in California on the occasion of the landing of the *Discovery* flight on Oct. 3, George Bush stated, "I am fully and utterly committed to the U.S. space program." Bush supports the 1996 deployment of the space station, but will not state exactly what kind of fight he is willing to lead to make sure the funding is secured to do so.

If a Bush administration were to follow in the footsteps of its predecessor Republican administration, the space station program is not assured. For the past two years, the Reagan administration has slashed the budget requests that NASA has made that would have allowed the space agency to be able to meet the original schedule, to have the station operational by 1994. The space station program is about $2 billion in funding behind where it was projected to be by 1988.

The Congress has funded the station only through March of next year. By that time, the new President must decide if the program will continue, and at what pace. The space station budget for the rest of the fiscal year must reach at least the $900 million mark, which was the NASA request.

To our international partners, there is no question as to why the station must be built. Prof. Reimar Luest, the director general of the European Space Agency (ESA), stated at the Sept. 29 signing ceremony that the intergovernmental agreements "should lead us beyond the year 2000." Robert De Cotret, the minister of state for science and technology for the government of Canada, stated, "The space station program will find our astronauts working together in space. More than that, it will eventually permit them to go beyond the Earth's orbit to new places in our galaxy and beyond. All this awaits us. It awaits our children and our grandchildren.



NASA

Artist's concept of phase one of the permanently manned Space Station, produced by Rockwell International. Elements provided by international partners—the European Space Agency, Japanese laboratory modules, and Canadian Mobile Servicing System—are part of the phase one configuration. An orbital Maneuvering Vehicle is shown flying away from the Station.

And that's the meaning of this day."

The question of the long-term future of the U.S. space program is back on the agenda, after a two-and-one-half year hiatus since the *Challenger* explosion. The National Commission on Space report and other initiatives in long-range planning were buried under the rework of the Shuttle program and the exit of James Beggs as NASA administrator, thanks to the Department of Justice.

It is now time to pull out those reports, and implement them. But one of the most disturbing features of Bush's space policy is his decision to reestablish the National Aeronautics and Space Council. This hodge-podge of representatives of various agencies who would like to have a say in space policy would only delay the planning and implementation of any program.

By using a similar group, the Senior Interagency Group for Space—which included people from the Commerce and Transportation Departments and the Office of Management and Budget, in addition to NASA and the Department of Defense—the Reagan administration succeeded in delaying a decision on replacing the *Challenger* orbiter, for example, for eight months.

Our foreign partners have stuck with the space station program over the past four years, through the thick and thin of budget cuts, schedule stretch-outs, and redesigns. They are committed to contribute more than $6 billion worth of hardware for the station, pay for more than 12% of the operating costs, and launch their segments of the facility.

The international partners will train and fly their own astronauts, and coordinate the international use of this facility with the United States. The space station *Freedom* is the largest international cooperation program in history.

There is no doubt about their commitment; it is the U.S. commitment that is in question. No multi-year, multibillion-dollar U.S. space effort can move forward without uncompromising and vigilant support from the White House.

Since the *Discovery* flight, there has been renewed interest around the nation and even in the media for a manned mission to Mars. This proper goal, which would give purpose to space activities for the next 40 years, must be done from the standpoint of colonizing space. That requires the step-by-step buildup of infrastructure in space, the same way industrial development has proceeded on Earth.

The *Discovery* flight showed the skeptics that we could get the Shuttle back into space, but we already had 24 successful flights before it proved that. The question on the agenda now is, where will the United States go from here?

Infrastructure for the trip to Mars

Regardless of what you have heard on television, the space Shuttle is not simply a "truck" that goes back and forth to Earth orbit. Because NASA recognized in the early 1970s, when the program was authorized, that it would be years before a space station would exist, engineers built into the Shuttle the capability to make full use of the human beings who fly the vehicle.

Though its primary mission is generally the deployment of spacecraft from the payload bay which cannot easily be launched on an expendable rocket, the Shuttle is actually a temporary space station, in orbit for up to 10 days, which is a test bed for the new technology, procedures, and activity that building and operating *Freedom* will require. It is the first step in building the infrastructure in orbit that will lead, in the next century, back to the Moon and to Mars.

The assembly techniques that will be needed to attach the laboratory, living, and other modules to the central truss of

Freedom will continue to be practiced by Shuttle crews. The air-, waste-, and water-recycling technologies that crews on the station will have to use, because they will only be resupplied periodically, will also be tested on Shuttle orbiters. Life-support related techniques should be tested when the astronauts can come right home, not when they have to wait weeks for a resupply at a space station.

The scientific experiments that have flown on every Shuttle mission since the second flight, have been used mainly to flight-qualify equipment and obtain preliminary results in materials processing, biological material separation, crystal growth, and other microgravity processes that may become commercial operations in the future.

This recent Shuttle flight is an excellent example of how this works. In the mid-deck of the orbiter were 11 kinds of experiments, designed to test a potentially beneficial effect of microgravity on materials. One of the most interesting was the Protein Crystal Growth Experiment, which included 11 different proteins. The scientific team is made up of people from universities, NASA, and the pharmaceutical industry.

Dr. Larry Delucas, from the University of Alabama, in Birmingham, explained at a briefing on Aug. 22, that crystallography is used to look at the detailed structure of large, complicated molecules, such as enzymes and proteins. When the structure can be determined, drugs can be designed that bind to the molecule, that prohibit the expression of side effects. In some cases, such as the reverse transcriptase flown on *Discovery,* one would want to inhibit the expression of the protein as a whole, as this one is key to the replication of the AIDS virus.

Dr. Delucas showed crystals that have been produced on Earth. Many of the crystals are too small to be of use. Due to convection in the growing solution as the crystals form, turbulence is introduced into the process. Often, "the crystals are large enough, but they're disordered in some way," he explained. On Earth, crystals often grow in shapes that are undesirable for practical purposes, and they tend to stick to the sides of the containers in which they are grown, which deforms the faces of the crystals.

In the microgravity of space, all of these problems are alleviated or eliminated, and experience has shown that the space-grown crystals are superior in all of these respects to the Earth-bound ones. The crystal-growing hardware flown on *Discovery* flew four times in less than one year on the Shuttle in the past. Delucas reported that the hardware was improved and modified after each flight, and that over 100 crystals have been grown on the Shuttle, so far.

The crystal growth science team is now looking at the design of the U.S. laboratory for the space station to make sure it can house a protein crystal growth facility, to make use of the superior results they have obtained in orbit.

The science work on each Shuttle flight includes Earth-observation targets, because from the first manned flights in the early 1960s, astronauts reported they could see more from space with their eyes than could ever be captured on film. Specific targets are determined by important ongoing events on Earth, and the particular flight path of the specific mission.

On *Discovery,* mission specialist Pinky Nelson took a look at the erosion in the Yucatan region of Mexico from Hurricane Gilbert, and expressed alarm at the extent of widespread fires burning in South America.

Some of the research conducted by the astronauts themselves, and in conjunction with scientists on the ground, is important for immediate intelligence about the Earth, but much of it is laying the basis for the next steps in space science and exploration.

Some initial proto-factories, developed from the experience of flying for short trips on the Shuttle, may be attached to the space station if they need human attention. At the point they become reliable, or if they cannot tolerate the small disturbances caused by people moving around the station, these manufacturing plants will be flying free of the station, but in an orbit which allows the astronauts to easily visit them.

As Shuttle flights resume and become more frequent, the deployment of the space station will be approaching. The space Shuttle will be the primary launch vehicle to bring up the modules, attach them, and transport the crews. By the mid-1990s, the life-support technology, equipment for scientific research, and construction techniques that will be needed for the station, must be ready, and that depends largely on a robust Shuttle fleet and schedule.

Additional transport infrastructure

The space Shuttle is designed only for flight in low-Earth orbit. But once the space station is operational, it will become a transportation node, like a train station, from which people delivered by the Shuttle can board other craft to go to other places.

From Earth orbit, it is not difficult to get to the Moon. Ninety percent of the energy required to traverse the quarter of a million miles of cislunar space, has been spent once you arrive at geosynchronous orbit, 22,300 miles above the Earth. Small transfer craft from the low-Earth orbit station might bring passengers to this geosynchronous transfer point, where they will board larger spacecraft to go to the Moon.

Space pioneer Krafft Ehricke suggested in the 1970s that enormous special cargo ships be developed to haul supplies to the lunar settlements and cities, and that they be nuclear powered. To use energy most efficiently, the ship from Earth orbit might not land on the Moon, but instead deliver passengers to a lunar-orbital taxi, which would land on the surface.

There will also need to be second-generation Shuttle-class vehicles built to launch from Earth to orbit, and some should be unmanned. These heavy-lift launch vehicles could deploy payloads that do not require human intervention, and will be key to the supply of the in-space infrastructure.

Specialized transport craft will be needed to travel from either Earth or lunar orbit to Mars. These huge ships flown in flotillas will have to be assembled in orbit, from components brought there by heavy-lift vehicles that, like the Apollo Saturn V rocket, can take hundreds of thousands of pounds of payload to space. The Shuttle, by comparison, can carry about 60,000 pounds of payload.

But since Mars is 35 *million* miles away at its closest distance from Earth, the propulsion technology for the transport ships will have to be more advanced.

Mars in days

It would be foolhardy to attempt to send people millions of miles away from Earth, without testing out the technology they need to survive much closer to home. Establishing settlements and cities on the Moon will allow mankind to learn to live in the hostile environment of space, only two days' travel time from Earth. Learning how to grow food in a partial-gravity environment, in extreme cold and two weeks at a time of night, will prepare future colonists for somewhat less harsh conditions on Mars.

The near-complete recycling of consumable resources, such as water, will actually be more demanding on the Moon, since Mars does have water and an atmosphere, but it will obviously be good training for the future Martian colonists.

Since the *Discovery* lift-off, there has been renewed interest and talk about human trips to Mars. But in an effort to lobby for a "crash program" to Mars, it has been suggested that the trip can be done simply by extending today's chemical propulsion technology. These "crash programs" make no attempt at a systematic colonization of Mars, but only a one-time space spectacular. Using the chemical fuels we have depended upon for the past 30 years, or even next-generation lunar nuclear systems, will not be adequate for moving human civilization to Mars.

The reason is that there are deleterious effects on people from extended exposure to the near-zero gravity of chemically propelled space travel, and also to the radiation that is encountered outside the protective Van Allen Belt around the Earth. Chemical or even nuclear propulsion missions would subject the travelers to months of space hazards, and leave the health of the crew to chance.

Developing third-generation propulsion using fusion energy as the power source would make it possible to arrive at Mars in a matter of days. Half the trip would be made under constant acceleration, and the second half under deceleration that would mimick the gravity on Earth, protecting the colonists from the effects of microgravity. There would be little chance of meteorite or radiation hazards on such a short trip.

Fusion energy research has been languishing over the past eight years of the Reagan administration, and paltry budgets have not allowed the aggressive development of the non-terrestrial applications of fusion energy, such as space propulsion. This work, centered at the Fusion Technology Institute of the University of Wisconsin, Lawrence Livermore National Laboratory, and the Massachusetts Institute of Technology, should be accelerated along with the overall fusion effort, to ready the Mars propulsion systems by the second decade of the 21st century.

Only a well-thought-out progression of technology developments, proceeding on a time line from today through the first quarter of the next century, will move us out to the planets. No "spectaculars" or short-cuts will accomplish the task.

The colonization of the New World was not carried out by "flying squads" making brief forays to the Americas. As Tom Paine, the former head of NASA, pointed out the night after the *Discovery* launch, half of the colonists who landed here to establish the Plymouth colony died the first winter. In comparison, we will have a much easier time colonizing Mars.

Without a long-term goal, none of the present space programs make sense. If the next administration wastes time doing yet more studies of what the nation's goals in space should be, the momentum may well be lost to define the programs for the next century.

The new people who are appointed by the President to carry out the next phase of space exploration should finally do what two generations of Americans have been waiting for them to do.