Mars by the year 2015

The President's National Commission on Space recommends an ambitious Moon-Mars mission, Marsha Freeman reports.

Twenty-five years ago, it appeared impossible that the United States would realize a manned Moon landing. President Kennedy's program appeared to his science advisers, to express an unrealistic optimism. Today, again at an apparently dim moment in the U.S. space effort, President Reagan's National Commission on Space has recommended a program of even greater scope and vision than the Apollo program. And, as in 1961, such a national commitment is precisely what is needed to ensure that the recent reversals in the space effort become a goad to greater progress.

In the introduction to the report, "Pioneering the Space Frontier," published by Bantam Books, the Commission states that their "vision is to make the solar system the home of humanity." It is not simply a question of doing long-term planning, the Commission says, but a renaissance in education and an orientation toward the future that is key. "Our leadership role should challenge the vision, talents, and energies of young and old alike, and inspire other nations to contribute their best talents to expand humanity's future."

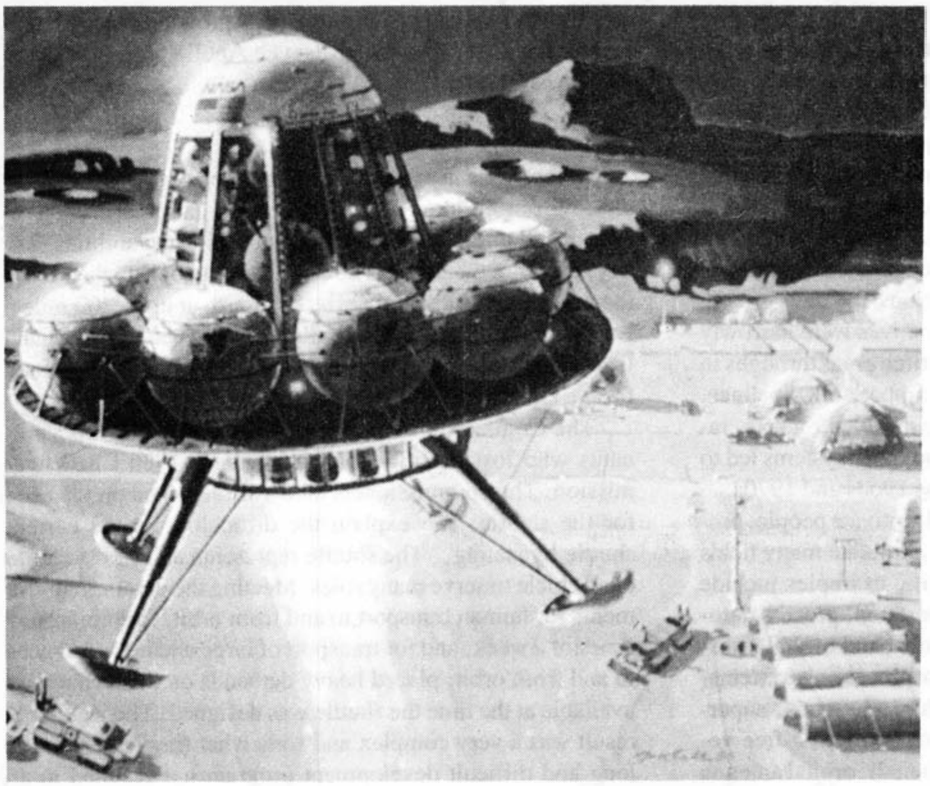
To accomplish this, the Commission has formulated a program for "exploring, prospecting, and settling the solar system," starting with a return to the Moon in the year 2005, and the first manned expedition to Mars by 2015. "We project," they write, "the growth of an initial Mars outpost to a Mars Base in about the third decade of the next century. "While that seems far away now, many of the people who will live and work at that Mars Base have already been born." The reason for going will be to bring human civilization to space—and this time, not just to visit.

The report has value "only to the extent that its recommended space goals for 21st-century America are adopted and acted upon," the Commission states. They recommend that the President and the Congress "direct the Administrator of NASA to review the Commission's findings and proposed space agenda, and by December 31, 1986, recommend a long-range implementation plan, including a specific agenda for the next five years."

For those who would rethink the entire policy of maintaining manned missions in space, which underlay the building of the shuttle, the Commission gives the following warning: ". . . it is imperative that the United States maintain a continuous capability to put both humans and cargo into orbit; never again should the country experience the hiatus we endured from 1975 to 1981, when we were unable to launch astronauts into space."

At a press conference on May 23 in Washington releasing the report, Commission chairman and former Apollo-era NASA administrator Tom Paine stated, "Stronger leadership and greater vision will be needed, but the expected benefits to America and the world will greatly outweigh the costs. Our report recognizes that the final decision will be made by the American people through its leaders in Washington. The Commission," he continued, "is therefore not prophesying, but describing what the United States can make happen through vigorous leadership in pioneering the space frontier."

The report outlines the following milestones for NASA to achieve:



This artist's rendition of a Mars settlement in the 21st century shows a Mars lander arriving from the Mars Spaceport.

All illustrations in this section are from "Pioneering the Space Frontier" (artist: Robert McCall)

- initial operation of the space station, on time, by 1994;
- a manned outpost on the Moon by the year 2005;
- a first manned mission to Mars by the year 2015.

In order to accomplish these goals, according to the report, the nation will have to push foward the frontiers in space transportation, new propulsion systems, life-support technologies to live away from Earth, and new sources of energy. Long-range planning at NASA, in addition to a steadily increasing level of funding indexed to the Gross National Product, are needed to accomplish the tasks.

The benefits to the United States will be seen in technology revolutions in energy, manufacturing, medicine, the life sciences, and the space sciences. Without the combined challenges of developing and deploying technologies based on lasers, plasmas, and new physical principles for the Strategic Defense Initiative and the Moon-Mars mission, the nation will not be ready for the 21st century.

Major milestones

From the outset, the report demands a commitment by the U.S. government to accomplish these goals, giving no quarter to the current mad push toward trying to commercialize the space program out of existence: "As formerly on the western frontier, now similarly on the space frontier, Government should support exploration and science, advance critical technologies, and provide transportation systems and administration required to open broad access to new lands. The investment will again generate in value many times its cost, to the benefit of all."

The Commission recognizes the synergy between the manned and unmanned space programs. They call for an "aggressive space science program" which includes studying the structure and evolution of the Universe, our Galaxy, and our Solar System, including the emergence and spread of life. Space science research should include astronomical facilities in Earth orbit and on the Moon; unmanned sample return missions from planets, moons, comets, and asteroids; a global study of the Earth; studies of the Sun; the search for planets around other stars; and the study of long-duration effects of micro-gravity on life.

The report outlines specific technologies which must be advanced for the overall program to be possible. These include the development of the aerospace plane and advanced rockets, aerobraking for orbital transfer vehicles, closed ecosystems for living in space, electric launch and propulsion systems, nuclear electric space power, and tethers and artificial gravity facilities in space.

The major milestones for the next 50 years, according to the report, are the development of new cargo and passenger transport vehicles by the year 2000, and extended use of the space station, which should be well in use by then. Five years after that, robotic lunar surface operations would have done detailed surveys of the Moon, and the first permanent outpost for astronauts would be started.

During the following decade, detailed unmanned exploration of Mars would be completed, with samples returned to be examined and evaluated. By the year 2015, the first human outpost on Mars would be established, followed by colonization.

The commissioners were undoubtedly able to imagine the reaction of budget-balancing Congressmen and accountants in the Office of Management and Budget, to this "exciting vision of our next fifty years in space." They therefore specify, in the introduction, the substantial economic benefits to be derived from challenging the space frontiers:

"As we learned in World War II, government-academic-industry teams mobilized to accelerate advances in science and technology can build the foundations for new growth industries even though the original objectives were narrowly focused on military requirements. Wartime breakthroughs in jet propulsion, antibiotics, synthetic rubber, oil pipelines, nuclear energy, microwave radar, liquid-fueled rockets, radio guidance, electronic computers, and other systems led to America's high growth industries of the 1960s and 1970s.

"The programs we recommend will motivate people, provide new standards of excellence, and stimulate many fields of science and technology. . . . Specific examples include artificial intelligence, robotics, tele-operation, process automation, hypersonic flight, low-cost global and orbital transport, optical communications and data processing systems, ultra-high-strength and high-temperature materials, supercomputers, wireless power transmission, pollution-free vehicles (electric and hydrogen-oxygen fueled), orbital antenna farms, closed-cycle ecology biosphere operations (which could revolutionize intensive agriculture), and myriad others."

In the last 50 years, according to the Commission, "Government-sponsored research and development created 'enabling technology' in aeronautics and in communication satellites." During the next 50 years, the government should provide the "enabling technology" for entire orbiting industrial parks.

To open up the Moon for industrial development and a new economic base of activity, the enabling technology will be transfer vehicles from low-Earth orbiting space stations. "When that second link in our space transport system is completed," the report says, "the event will compare in significance to the driving of the Golden Spike in Utah more than a century ago, that marked the completion of the transcontinental railroad."

Will we have to put the country in hock to achieve these ambitious space goals? The Commission projects that the rate of growth of the Gross National Product in the next 50 years, will average the same 2.4% that it did in the past 25. They recommend that the amount of money spent by NASA each year be a fixed percentage of the GNP, and that that percentage need only be half of what it was during the peak Apollo funding years. This would mean that the NASA budget would be about 2% of the GNP, rather than the 4% it was during Apollo, or the 1% it is now.

In a speech in the summer of 1985, Commission chairman Paine remarked that the most cost-effective space programs were done on a "crash basis," like Apollo. He described the capabilities available from a modestly growing NASA budget over the next 50 years, as "seven Apollo programs in the 20-50 year period."

Why we need the shuttle

Before we can even think of going back to the Moon, or sending our children off to Mars, this nation will have to extend and upgrade its space transportation capabilities. Today, the United States has no way to take people to the Moon; the space shuttle can only orbit the Earth at up to 300 miles. But the shuttle will be our railroad to a space station, and from there, other space transport vehicles will be designed for the lunar trip.

The Commission report is dedicated to the seven astronauts who lost their lives in the January 1986 Challenger mission. The commissioners take a strong stand on the need for the shuttle, and explain the difficulties in the current shuttle by stating, "The shuttle represents an effort to build one vehicle to serve many roles.
ments for human transport to and from orbit, for orbital stay times of a week, and for transport of large and heavy cargoes to and from orbit, placed heavy demands on the technology available at the time the shuttle was designed. The inevitable result was a very complex and somewhat fragile vehicle. A long and difficult development program has resulted in an orbital transport system that is both expensive and technologically demanding to operate.

"Nevertheless, the space shuttle is a technological triumph and a magnificent achievement both in pioneering winged flight into space and in providing a reusable vehicle for spaceflight. . . . It has opened the Highway to Space."

Next-generation space vehicles

By the turn of the century, our current space shuttles will be obsolete, and at the end of their operational lives. The Commission states that the shuttle "should be replaced by a new vehicle designed to meet all requirements for the transport of passengers and high-value cargo to and from orbiting spaceports."

"This vehicle, optimized for passenger transport, may be smaller than the shuttle. Since the space station will have been operating 5 or more years before passenger transport vehicles (PTV) become operational, they will not need the capability for extended, independent stay times in orbit. . . . PTVs must be designed for reliable low-cost operations, even if this means increased development costs."

The Commission recommends that research into two "essentially different but complementary means to cost reduction" for passenger flight be conducted in parallel, to develop the next-generation Earth-to-orbit transport system. The first is the air-breathing aerospace plane, which the Air Force and NASA are now examining.

The second line of research, is to develop more advanced rocket systems for orbital travel, possibly using various kinds of hybrid engines, using both liquid hydrogen and petroleumbased fuels. By 1992 both programs should provide enough data for the nation to make a policy decision on which technology should be developed to replace the space shuttle.

In addition, a specially designed cargo transport vehicle should be developed, to separate the freight requirements from the passenger requirements. The goal would be to reduce to about $200 the cost of getting a pound of cargo into orbit. These vehicles would likely be one-way only, similar to the Progress cargo ships which the Soviets have used to resupply their space stations.

Once the space station is operational, it will provide the technology base and infrastructure to build more specialized orbiting facilities. The Commission recommends the construction of a series of Spaceports, as transportation hubs in space. These will be used for the storage, repair, supply, maintenance, and launch of orbital transfer and other space-based vehicles.

From the Earth-orbiting Spaceport, new orbital transfer vehicles (OTV) will depart, to higher Earth orbits and the Moon. They could be chemically propelled, based on a modular design, where more fuel tanks could be added for longer journeys. The most energy-efficient way to bring this OTV back to the Earth Spaceport is to use aerobraking. This technique uses the upper atmosphere of the Earth to slow down the vehicle, so it can dock with the Spaceport, conserving its onboard fuel.

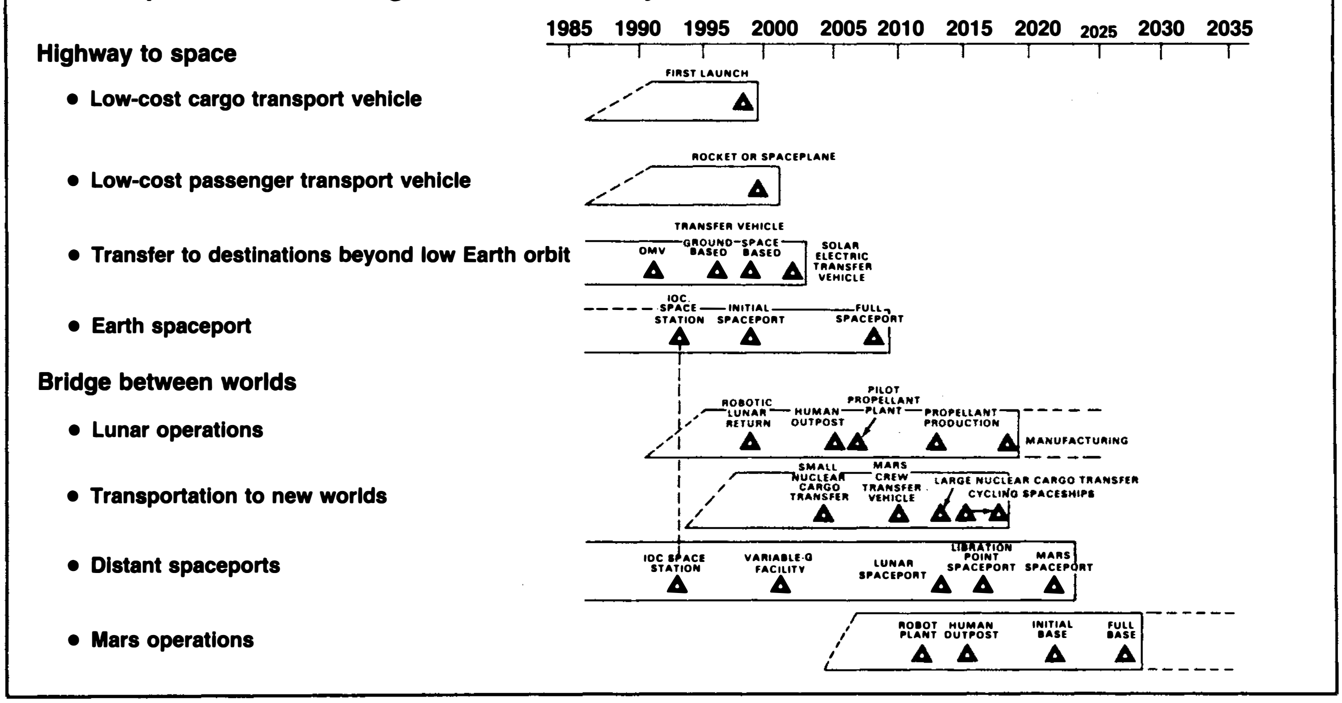
The OTV would make use of in-orbit maintenance, refueling, testing, and repair at the Spaceport. The first OTVs could be unmanned, followed by passenger transports. The report warns that for this schedule to be maintained, with OTVs operational by the turn of the century for returning to the Moon, the "U.S. space station must be kept on schedule for an operational capability by 1994, without a crippling and expensive 'stretch-out.'"

Traveling 35 million miles to Mars, however, requires a completely different generation of spacecraft than those which can travel the quarter of a million miles to the Moon. Using the most advanced technologies based on today's propulsion, a Mars trip will require minimally six months of travel, as opposed to two days to the Moon. As Dr. Paine remarked at his press conference, the Commission's projections did not assume any breakthoughs in basic science. More advanced technologies, such as fusion propulsion, could certainly shorten the trip time.

But it is possible that more conventional transport will have to be relied upon for the first Mars trips, in the second decade of the next century. The report suggests the development of "cycling spaceships" which only go from Earth's Spaceport to a similar orbiting Spaceport at Mars. Similar in concept to the Mars Delivery Vehicles proposed by space scientist Krafft Ehricke in 1968, these spaceships could save time and energy by not slowing down at either planet, but transferring passengers to space "taxis," which would go to the Spaceports.

The cycling spaceships are actually moving space stations, with substantial research facilities, and the other things passengers would want to have on board, since they will be living there for six months.

NASA's plan for colonizing the inner solar system



The Moon is so close to the Earth, that running "home" in case of emergency is still possible. Not so for Mars. When humans go there, they will have to initially take with them all of the food, water, air, other consumables, and equipment they need. They will have to be able to perform surgery and take care of any other emergencies.

No one would think of sending the first Mars crew out with technologies they are trying for the first time, so the Commission report wisely recommends that, "many of the systems needed for reaching outward to the planet Mars will be proven in the course of work in the Earth-Moon region."

Before full-scale lunar development can begin, a Lunar Spaceport will be in orbit, to "handle incoming and departing transfer vehicles. . . . The Spaceport will become a hub of activity as tons of habitation modules, cranes, scientific devices, lunar rovers, and processing and manufacturing equipment descend upon the Moon's surface."

"Return traffic from the Moon will provide lunar soil for shielding and processing," at the Spaceport itself, "thus providing oxygen, lunar metals, and possibly hydrogen," the report states. Because lifting material from the Moon only requires 5% of the energy it takes to lift the same mass from the surface of the Earth, it will eventually be much cheaper to bring materials to the Earth space stations from the Moon, rather than from the nearer Earth.

Once lunar operations are in place, work to lay the basis for the Mars mission will include the development of self-sustaining biospheres, where virtually all waste is recycled and reused, and where food is grown for "local" consumption. Robotic industrial processing techniques, and automated factories that will be needed on Mars, will be "debugged" in orbital factories, and on the Moon. Full lunar industrializiation—including mining, propellant production from the Moon's abundant oxygen, the processing of metals and other raw materials, and manufacturing and fabrication—will be the "growth industries" of the next century.

A laboratory to study effects of low gravity

As human beings move out to live in space stations, on the Moon, and then on Mars, they will be faced with the prospect of living in environments that have almost no gravity, or only some fraction of the one-g we experience on Earth. Scientists are still discovering what the long-term physiological effects are of leaving the one-g of our home planet.

The report of the National Commission on Space recommends establishing an Earth-orbital facility where the gravity can be varied, anywhere from near-zero to one-g. The laboratory would be rotated to simulate gravity through centrifugal force. The major question that scientists would seek to answer using the facility, is: "What gravity level is needed to prevent the deleterious effects of less than Earth gravity?"

"If one-sixth gravity is adequate, then long-term habitation on the Moon will be practicable; if one-third gravity is adequate, then humans can inhabit the surface of Mars," the report states. "What are the effects of return from low go to Earth gravity?" This is a crucial question to be answered, and "experiments to settle these questions will have to be carried out over long periods of time," the Commission cautions.

Space shuttle crews now spend up to 10 days in the microgravity of Earth orbit, without any noticeable long-term effect. But U.S. medical authorities have reported that Soviet cosmonauts who returned to Earth in 1984, after spending 237 days in orbit, emerged from the flight with symptoms that mimicked severe cerebellar disease, or cerebellar atrophy.

The cerebellum is the part of the brain that coordinates and smoothes out muscle movement, and the cosmonauts required about 45 days of normal Earth gravity before their muscle coordination allowed them to remaster simple children's games, such as playing catch, or tossing a ring at a vertical peg.

It has been observed for years, from both the U.S. Skylab program of the early 1970s, and the near-continuous use of Soviet space stations, that long-term space habitation produces problems of cardiovascular deconditioning, the demineralization of the skeleton, the loss of muscle mass and red blood cells, and impairment of the immune system.

The variable gravity research facility would be used for basic scientific studies of these questions. Eventually, it could be used to slowly accustom future space colonists to a lower-gravity planet, by having them live in progressively lower-gravity environments.

The laboratory would also be used for other scientific disciplines, in addition to biology. These would include physics and chemistry and also the long-term testing of synthetic biospheres that will support life during the voyages to Mars, as well as on the surfaces of the Moon and Mars.

It may well be the case, that humans who leave Earth to inhabit other worlds may find it difficult, if not impossible, to return to Earth, because while it is possible to rotate space stations to simulate gravity, the low gravity of the Moon and Mars themselves cannot be altered in that way.

A Mars-orbiting Spaceport will "serve as a base for scientific investigations of the Martian surface, and will be a node for incoming and outgoing crews and equipment." In terms of a Mars outpost, the report poses the possibility that the tiny Martian moon Phobos, could be used virtually as a space station, as it orbits only 6,000 miles above the Martian surface.

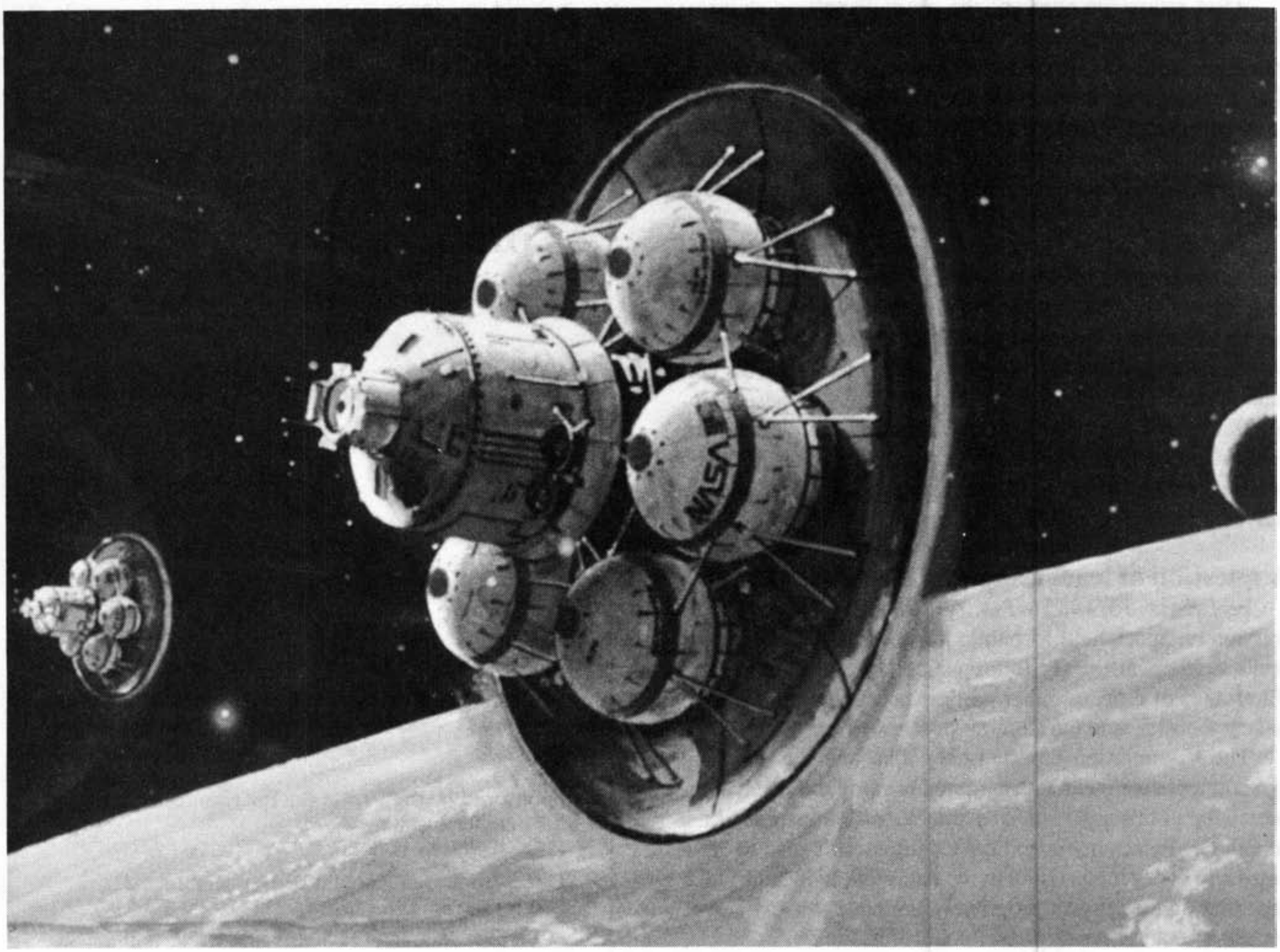
Because Phobos is so small, it will require very little energy to land there. Phobos may be rich in volatile elements, such as oxygen and hydrogen, and therefore a processing plant might be established there. "The propellants obtained from this plant will support future Mars operations, and greatly reduce the necessary cargoes transported over the long supply line from Earth."

"The great distance of Mars will dictate not only the development of complete and fully redundant biospheres for operation there, but also the establishment of two or more bases, for example, both on the planetary surface and in orbit, so that a serious problem occurring in one of the bases can be overcome by quickly transferring personnel from the affected base to another," the study explains.

The commissioners also examined the kinds of surface transport required for operations on Mars. "There is a logical sequence of experience for the design of land-roving vehicles both for the Moon and for Mars. . . . For long-distance traverses of the surfaces, there will be enclosed vehicles, equipped with full life support systems, in which people can live and work in shirt-sleeve environments for many days."

"For short trips in the vicinity of outposts and bases, vehicles roughly similar to the lunar rovers of the Apollo era will be used." In these, the colonists will have to don space suits. For observation, surveys, and checkout of changing conditions, remotely piloted Mars airplanes are likely to be useful, because, unlike our Moon, Mars has a thin atmosphere.

The Commission describes its report as an "economical,



Two transfer vehicles are shown here being slowed down (aerobraked) by the upper atmosphere of the Earth during their return to a space station. A large, ceramic disk acts as the aerobrake. Behind the disc are six spherical propellent tanks and a cylindrical module containing astronauts.

phased approach." Each step lays the basis, or provides the enabling technology, for the next. The goals are clear, and holding back on any one, delays the completion of the next. By setting such long-term goals, the Commission concludes one of the most important changes could be in education.

Revitalizing science education

"When Sputnik 1 penetrated the vacuum of space in October 1957, the reverberations shook the technological and educational underpinnings of the United States. A series of science education initiatives, including the National Defense Education Act of 1958, triggered a reformation of Amercia's educations system."

"This momentum has not been sustained; once again our Nation is confronted with the necessity to revitalize education. . . . A citizenry able to understand and appreciate our Nation's space program is a key ingredient to the future of the program. The Commission believes that current weaknesses in our educational system must be corrected to ensure a vital 21st-century America."

After reviewing some of the most disturbing statistics dealing with the decline in the quality and quantity of science education, the report makes some specific recommendations. The disciplines of science that are already represented in the space program, including nearly every branch of physics, chemistry, life sciences, medicine, and biology, will be joined in the future by experts in even broader technical fields, such as agronomy.

The Commission recommends establishing a National Space Laboratory, which would allow students to carry out experiments in orbit as part of their educational program. It suggests that the Congress authorize NASA "to create a fellowship program in space science and engineering. This will help attract the best students to pursue careers in these disciplines and permit access to space careers by highly qualified young people regardless of their financial situation." The report also calls for NASA to undertake a program to upgrade university space research equipment.

A question of leadership

From Sept. 13, 1985 to Jan. 17, 1986, the National Commission on Space held 15 public forums to allow citizens to make suggestions on the future of the U.S. space program. Thousands of citizens either participated in these meetings, or sent their ideas to the Commission in writing.

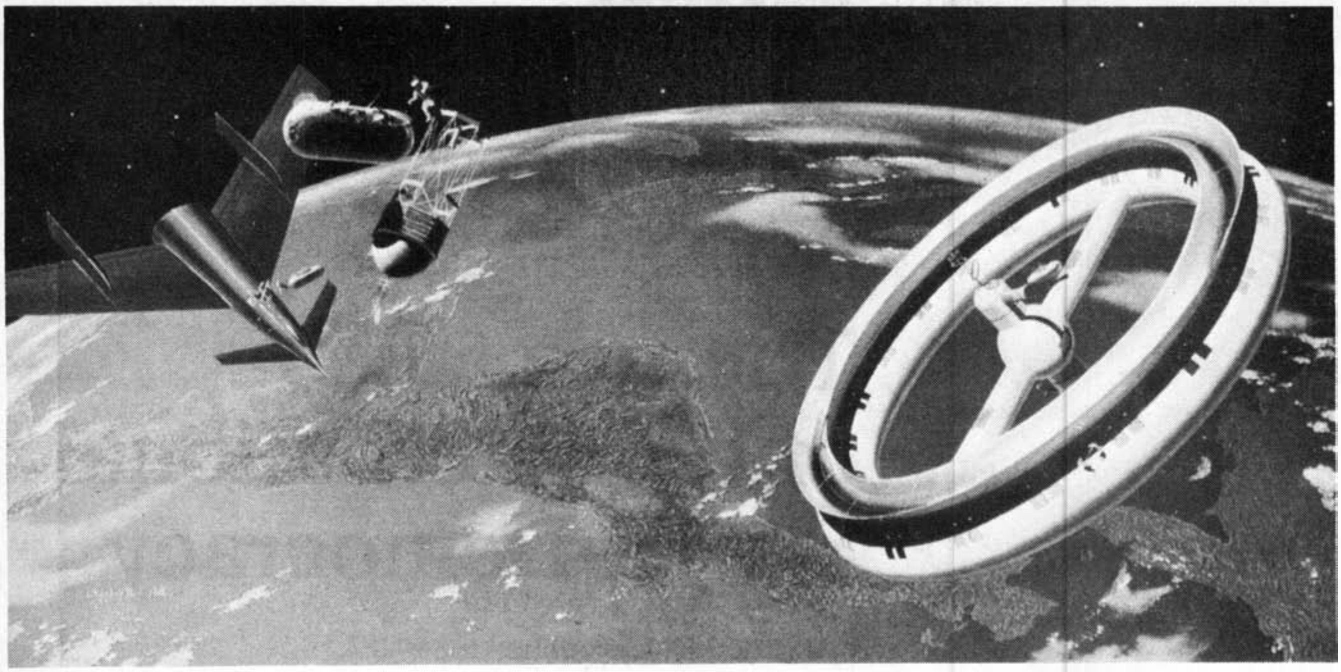
The Commission report, rather than being a technical government document with a limited printing, has been commercially published, and is available in bookstores. Last month Dr. Paine announced the Commission's plan to get a copy into every high school in the nation. A half-hour video tape film on the 50-year program is available free of charge, for use by schools and others.

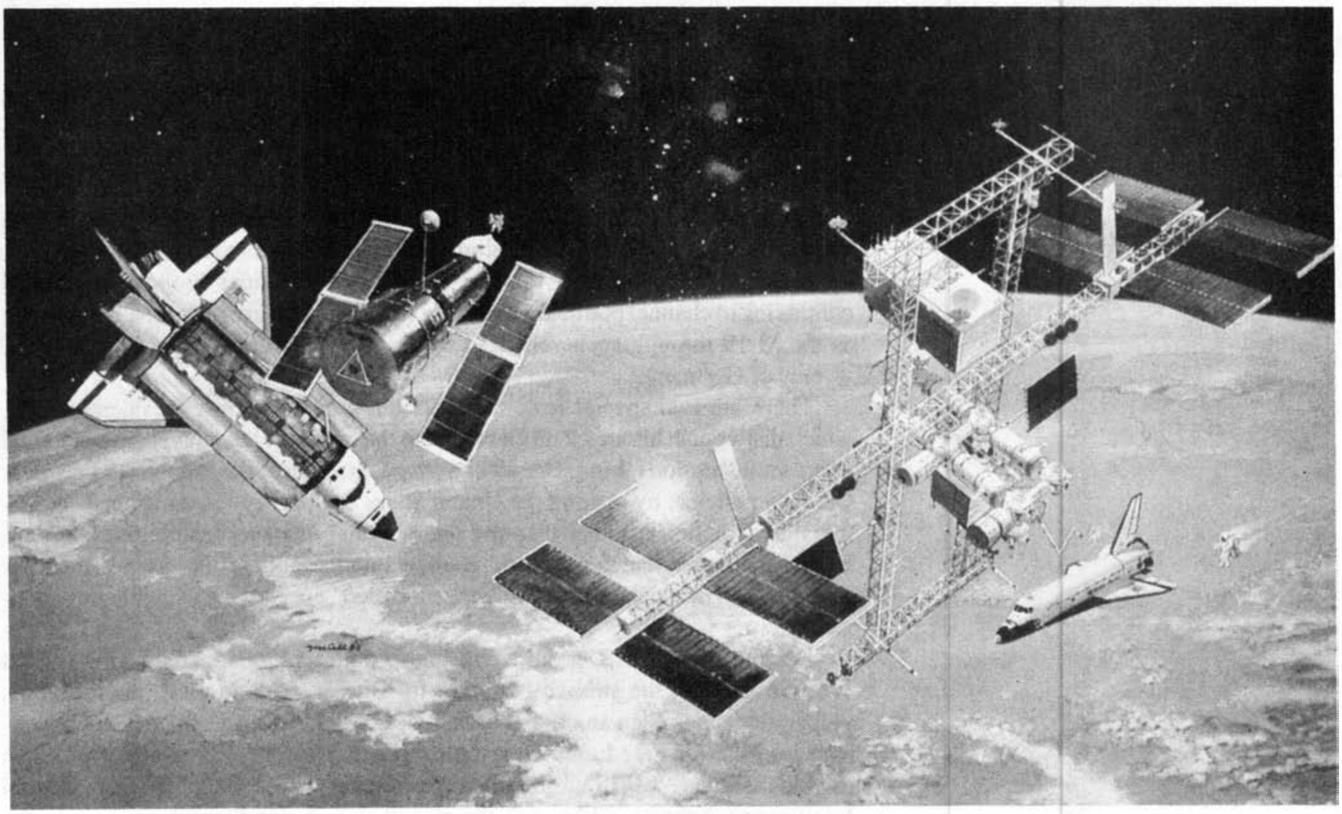
For Dr. Paine, this was not his first experience with trying to project long-range goals for the space program. As the head of NASA during the time of the first Apollo lunar landing, he was involved in the September 1969 study titled, "America's Next Decades in Space." This report presented four possible scenarios for the post-Apollo future of the space program.

At the fastest rate, NASA projected that the first manned expedition to Mars could take place in 1981. This would have been preceded by a space station in 1975, which by 1980 could have housed 50 astronauts and crew. An Earth-to-orbit shuttle would have been operational by 1975, and a space tug to go to the Moon would be ready a year later.

Needless to say, this plan was never implemented. The reason was the same budget-cutting economic policies which the Reagan administration is trying to foist on the space program today. This time, Paine and the other members of the Commission have decided to take their plan to the American people, to drum up broad-based support for aggressive space goals.

If policymakers in Washington had enough vision to look 50, or even 20 years into the future, they would see how the decisions they make today—to replace the Challenger orbiter, to build the space station on schedule, to upgrade the space science programs—will determine whether we can start implementing the necessary Moon-Mars programs outlined in the Commission report.





The report of the President's Commission, "Pioneering the Space Frontier," with its beautiful color illustrations and popular presentation, is a polemical call for the continuation of the vision of the first generation of space pioneers, as these paintings—the frontispiece of the book—illustrate. "While predicting the future can be hazardous, sometimes it can be done," the caption reads. In 1951, artist Chesley Bonestell painted the vision of space scientist Wernher von Braun (above), showing a reusable launch vehicle on the left, a space telescope near it, and a rotating space station on the right. Artist Robert McCall has produced a modernized rendition (below) of how this vision will actually be realized, in the early 1990s. It shows the space shuttle, the Hubble space telescope, and the space station.