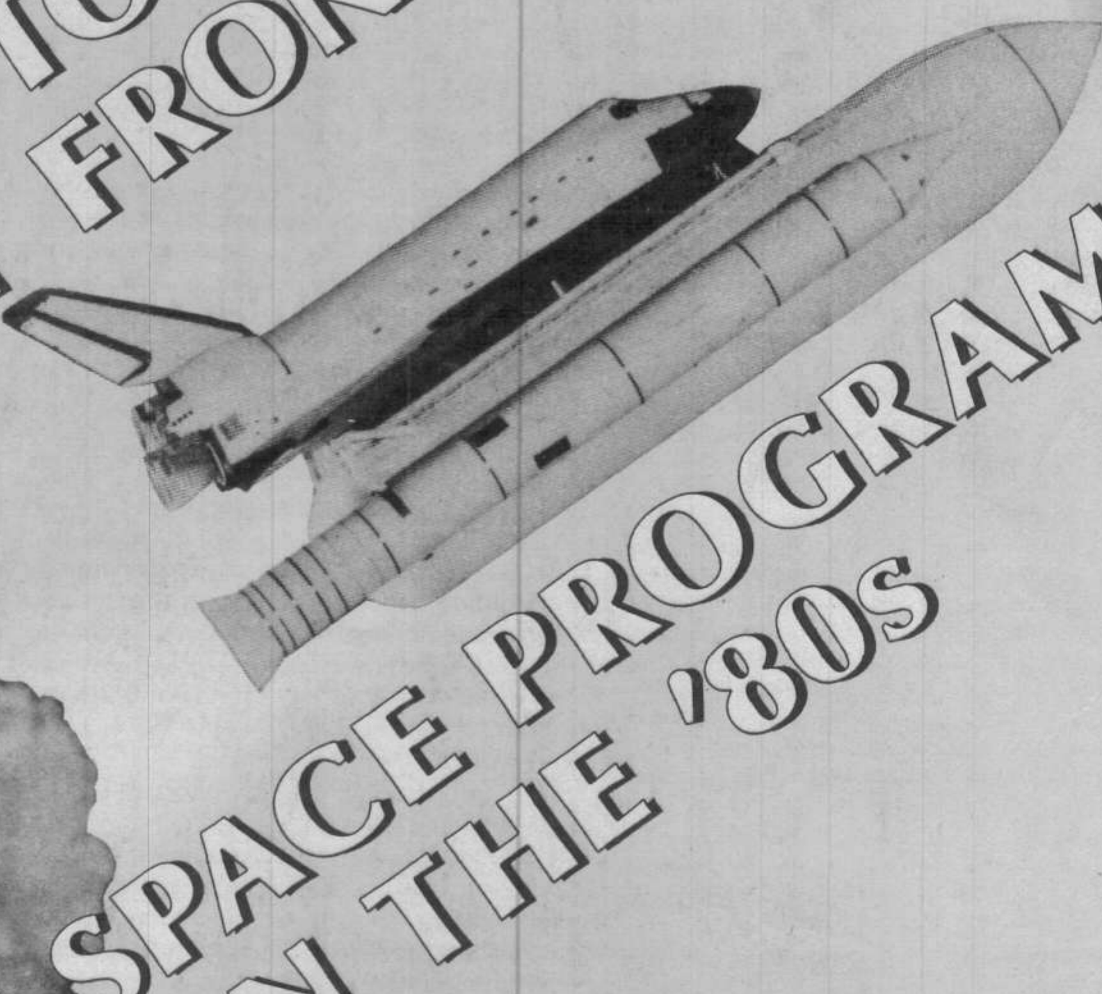
FUSION

SPECIAL REPORT

ON TO THE NEXT FRONTIER



THE SPACE PROGRAM IN THE '80s

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FOREWORD

On April 12 the space and airship Columbia was launched from the Kennedy Space Center and was recovered in California on April 14. The extraordinary flight of the Columbia has a significance far beyond the technical achievement it represents for Americans. As great as this achievement is, the more important fact is that the edges of the "new ocean" of space are now accessible to our civilization. The services, products, and defenses of this country and of free nations everywhere can now be extended beyond the confines of the atmosphere and the surface of the planet Earth.

Although we now have this fantastic new capability in hand, it is still not certain that the United States will reach out and fully grasp the opportunities it provides. What is lacking is what has been lacking since the latter years of the Johnson administration, namely, leadership.

The Reagan administration is now presented with the opportunity to articulate a purpose for U.S. activities in space, a purpose that establishes once and for all a permanent commitment to compete continuously and successfully in the development of space.

The permanence of a U.S. commitment to space could begin to be reflected with a start on a multipurpose American station in space for use by 1990 for a variety of purposes. Clearly this is the ultimate near-Earth nondefense utility of the Space Shuttle and we should plan to get on with it in the near term.

As important as the public, commercial, and defense applications will be, there is an even greater need to be served by the success of the Columbia. All of us for a shared moment once again stood with John and Crip on the edge of the universe. Americans need to step beyond Earth's shores of this new ocean of space and out once again to test heart and soul against the frontier of the unknown.

The final issue is, where are we going with our civilization? Historically the oceans of the Earth have been the place where the ebb and flow of civilization has taken place. Now that ebb and flow is moving into space. We literally have no alternative. We are talking about the movement of civilization into space.

—Senator Harrison "Jack" Schmitt

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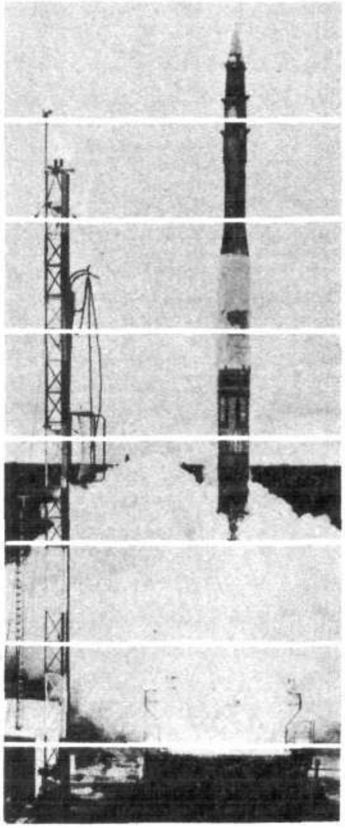

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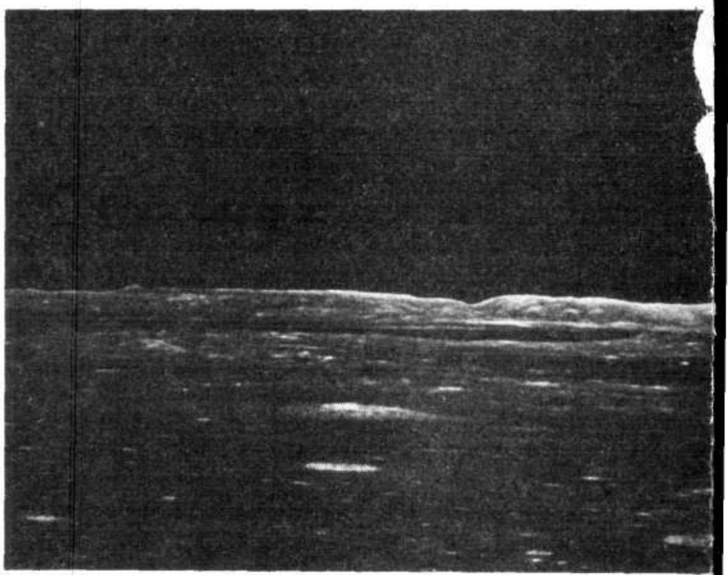
INTRODUCTION

The sublimity connected with vastness is familiar to every eye. The most abstruse, the most far-reaching, perhaps the most chastened of the poet's thoughts crowd on the imagination as he gazes into the depths of the illimitable void.

—James Fenimore Cooper
The Pathfinder



During the triumphal flight of the first component of a permanent base for man in space, the Space Shuttle Columbia, America's hope and pride was reawakened by the vision of a new frontier. More than 1 million Americans traveled to Cape Canaveral, Florida to cheer on the Columbia. These, and the millions more who cheered before their television screens, were delivering a mandate for the progress and advancement of science.

Yet, during the same week in Washington, D.C., the budget proposed for the National Aeronautics and Space Administration was less than half (in real dollars) the budget that funded the Apollo Moon-landing program a decade earlier. If NASA were today to have the research and operational capability it commanded at the height of the Apollo effort, it would have to receive a budget of $14 billion. Instead, the fiscal year 1982 allocation for the space agency is just over $6 billion and still threatened with cuts by the Office of Management and Budget.

Why a Space Program?

The various petty arguments against a fully funded, aggressive space program have been answered many times: Space exploration is economically attractive because it pays back in increased economic activity and technological development up to 30 times its initial cost; space exploration is a national defense priority because it truly is the new "high ground"; the development of space contributes to the solution of social and economic problems on Earth, in particular, enriching education and manpower training.

But the real reason for a space program is much simpler—it is man's responsibility to explore and colonize, first our own solar system and then the galaxy. As Senator Schmitt says in the foreword, "We are talking about the spread of civilization into space." This is man's calling, his reason for existence.

Lyndon H. LaRouche, Jr., a founder of the Fusion Energy Foundation, put it this way:

> Even if we had achieved such abundance that we needed no new scientific discovery, no new technological advances, in order to satisfy human needs to the full for an extended period of time, we would still need to conquer space. Because, once the human race ceases to progress in the work of mastering through practice the lawful organization of the universe, the human race becomes a gang of lotus eaters, of parasites. The essential thing is that we must always work to advance science, to make some contribution to the breakthroughs in this year or the following year. Because it is the nature and the condition of our existence, our moral existence, to do so.

All modern religions agree that man was created in God's image; not in physical shape, size, or color, but in respect to God and man's *differentia specifica*—as creators. Man exists to continue creation as an unending process of perfection and development. The pagan chants of the environmentalists to the contrary, man's stay on Earth has vastly improved the appearance and habitability of the planet.

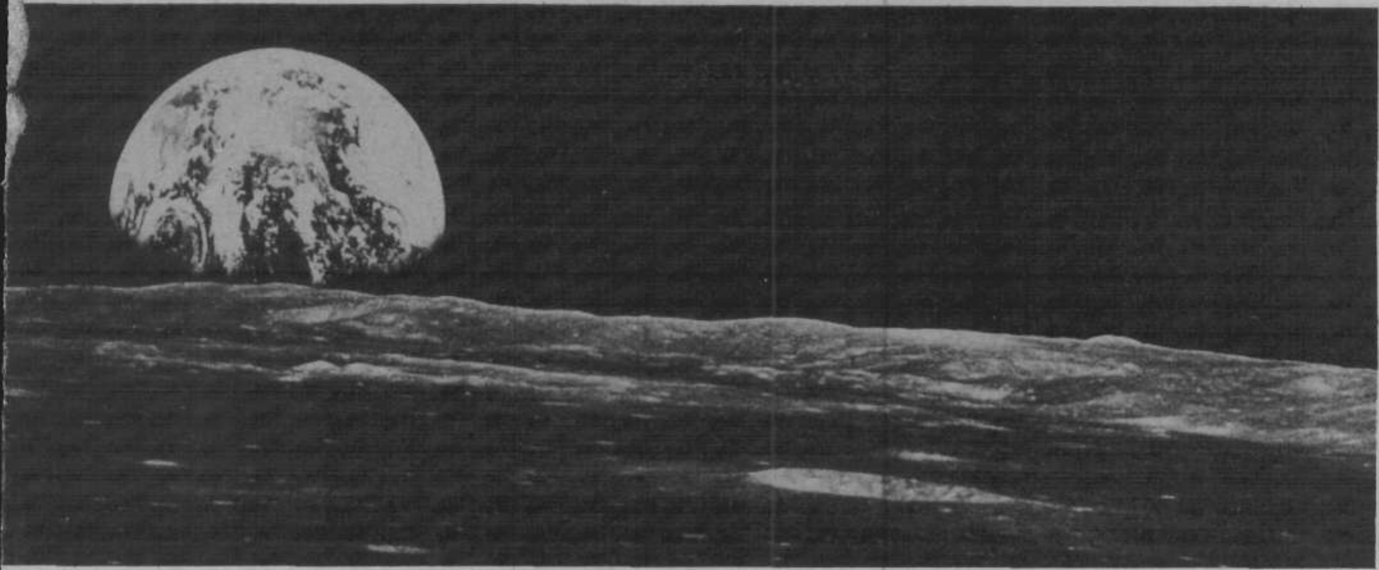
Our job does not end at the boundaries of our tiny planet. The illimitable void that beckoned Cooper demands our creativity. It must be explored, inhabited, and perfected for its higher purpose.

Of course, the space program must be economically, militarily, and socially justifiable—but none of these considerations alone makes it necessary. It is certainly true that America needs space to grow but, even more, space needs a growing America to progress.

A Strategic Plan for Space Development

Taking this responsibility seriously demands a strategic plan for the exploration and colonization of the solar system. Our space program cannot be simply a collection of exciting missions. It must be a campaign, a peaceful war against a nonhumanized environment; and we must have a strategy for winning.

Any successful campaign for exploration and colonization must have an overview of what forces can be marshaled, what objectives must be taken, and what lines of supply and communication must be maintained to con-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quer the new frontier. The strategy for the exploration and colonization of the solar system is largely unknown or forgotten today, although initially NASA's program was guided by such a plan.

Put yourself in the position of Queen Isabella, mustering her own force of explorers, mapmakers, scientists, and geometers. What must be done to explore and humanize a New World?

Phase one. The preparatory scientific reconnaissance missions must be sent out. For Christopher Columbus this meant map collection and study and astronomical measurements to determine the size and curvature of the Earth. For our New World of space, it means unmanned reconnaissance missions to find a path through space, to map out the hazards of space travel, and to pioneer the technologies needed for space flight.

In the first stages of space exploration, scientists had to answer some basic questions before any further progress could be made: Was it the case, as some scientists thought, that space was filled with small, very rapidly moving debris, small meteorites that would destroy the delicate ships and their power supplies in space? Was it the case that the intense radiation spewed from the Sun would kill any living creature that ventured above the Earth's protective ozone layer? Could an astronaut survive the eight-day journey to the Moon and back?

These questions had to be answered by using unmanned exploratory missions. Scientists have now answered all of them, of course, for space between Earth and the Moon, but other questions remain for exploration of the rest of the solar system. Titan, for example, one of Saturn's moons most conducive to colonization, has a surface and atmosphere of unknown composition. The plasma and radiation belts that surround it and connect it to Saturn are not understood or mapped. The first stage of any exploration must prepare for manned scouting parties.

Phase two. Columbus's expedition to the West was exemplary of the second phase of exploration and colonization. Here the technical problems of life support and transportation are the most immediate problems. In addition, mapping, more refined reconnaissance, and experimentation can be carried out with human beings in control of the mission.

Until 1979, all the manned flights of both the Soviet Union and the United States were of this type. Small parties of explorers were charged with the duty of making forays into the unknown, of finding the most tractable regions for man's next step into space. The Apollo astronauts and their forerunners were the explorers of space, the Columbuses and the Magellans who left nothing permanent in space, but who blazed the trail for their successors.

For Mars and beyond, we still wait for a Columbus.

Phase three. With the routes mapped out, seaworthy ships available for the Atlantic crossing, and trained navigators for oceanic travel, the way became open for the first colonists. These colonists had to establish a beachhead in the New World, setting up the first elements of the supply lines connecting the New World to the old.

For the region of space between Earth and the Moon, these beachheads are under construction, at least by the Soviet Union. The United States has yet to commit itself to the construction of a manned orbiting space station. However, the supply lines are being built by the U.S. Space Shuttle crews and the crews of the Soviet Soyuz space laboratory.

From the small beginnings of a space station and reusable spacecraft, the entire solar system can be developed. The Moon becomes the industrial base for the construction of new space stations, huge mining and manufacturing complexes, and astronomical laboratories, as well as the launching pad for colonization missions to other parts of the solar system. As one of our foremost space scientists, Dr. Krafft Ehricke, has put it, the Moon will become our "seventh continent."

The chief task of the first colonizers is, as it has been for all colonizers before them, to spread the best of their civilization to the New World, to humanize the solar system. Planets must be Earth-formed, giving them life and the ongoing capability to support life where none existed before. Planets must be inhabited, making them the stepping-stone for the next colonization teams. And planets must become laboratories for the expansion of human knowledge that is the means and end of this colonization.

Phase four. As the Spanish explorers found out to their dismay, a successful exploration and colonization campaign must be closely tied to the development of the mother country. The New World must embark on a program of codevelopment with the mother country in which each fosters the growth of the other. At present, the largest obstacle to undertaking a full-fledged colonization program based on the accomplishments of the first 20 years of the NASA space program is the decay of our Earth-based economy, the failure to develop it over the last 15 years.

Most critical to success of the space program and the development of the solar system is the expansion of advanced technologies and their industrial use on Earth. We must accomplish nuclear energy, the transition to nuclear fusion, the spread of high technology agriculture worldwide, and the development and investment in advanced industrial processes. The energy question is especially crucial. Without the widespread use of the cheapest, cleanest energy source we now have, nuclear energy, man cannot progress on Earth, let alone in space. Without investment in large-scale and widespread energy-intensive and capital-intensive industry based on nuclear energy, Earth's economy will become as weak and rotten as the Spain of Columbus's successors, an Earth unable to support colonies anywhere in the solar system.

The fantasies of the L-5 Society and its mentor Gerard O'Neill that space will be a decentralized utopia, a release valve for Earth's insoluble problems, are dangerously wrong. The L-5 litany is merely an argument for not developing nuclear technology, and its implementation would guarantee the destruction of space colonization. Earth and space are made or destroyed together; man's role is to perfect both simultaneously.

(1) A view of a Martian plain from dust-covered Viking 2.

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(2) Astronaut David R. Scott and the Lunar Rover at the edge of Hadley Rille.

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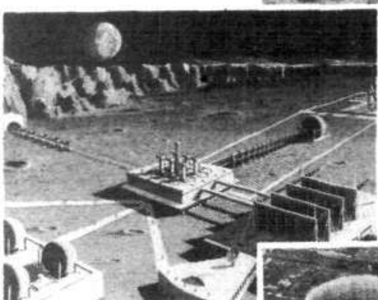

(3) An artist's depiction of a lunar industrial complex.

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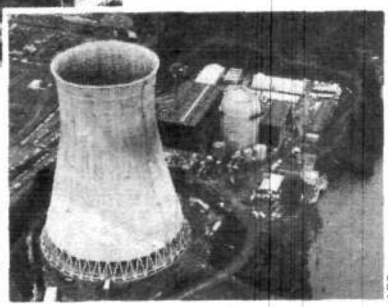

(4) Nuclear fission and later fusion are essential to support space colonization.

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The four stages of colonization.

Restarting Our Space Program

In spite of the "lost decade" of the 1970s, the space program has been the singly most successful project undertaken by the United States since World War II. As the only federal agency that even presumes to plan 10 to 20 years in advance, NASA has planned America's progress in science and technology. NASA is our primary scientific capability; every dollar cut from NASA's budget reduces America's strength more surely than any cut in the military budget.

Space exploration is a proven way to reinvigorate the U.S. industrial and technological capability, its leadership in productivity, and its skilled manpower. To accomplish these goals, NASA must be funded at a level sufficient to pursue the next step of space colonization—the establishment of a permanently manned space station, the Space Operations Center (SOC).

The natural continuation of the Apollo program would be the creation of this space station in near-Earth orbit as a transit point for satellites launched to high-Earth orbit or to the Moon and as the next step toward the establishment of a permanent colony on the Moon. The Soviet Union plans to have such an operations center permanently manned by 12 astronauts by 1985! At present, the United States has no plans to fund or launch the SOC.

As a continuation of the other phases of a space exploration and colonization program, these experiments must be funded:

- enhancement and speed-up of the Space Shuttle
- the probe of Halley's comet, a unique scientific mission possible during this decade
- the Large Space Telescope and the Gamma-Ray Observatory, a combination of experiments that will increase 200-fold the volume of the universe observable by man
- the International Solar Polar Mission, to provide the first glimpse of the Sun outside the plane of the ecliptic
- the Galileo mission to send unmanned probes to Jupiter and explore the inner layers of the planet
- the Venus Orbiting Imaging Radar mission to explore the surface of Venus and map the still unseen planet
- the Upper Atmosphere Research Satellite Experiment, to measure the chemical, magnetic, and physical features of the upper atmosphere of the Earth.

With a budget of the same magnitude as the Apollo program, approximately $14 billion a year, America can restart its space program. We must settle for nothing less.

PART I

Unmanned Exploration: Dawn of the Space Age

By the end of World War II, scientists and engineers knew that man was on the verge of developing the technology to escape from the Earth's atmosphere and send a craft into space, but sending man into space was a different problem. As the United States and the Soviet Union competed to launch a space satellite during the 1957 International Geophysical Year, the key question on everyone's mind was, "Could *man* go into space?"

Both the United States and the Soviet Union succeeded in sending aloft small artificial satellites during 1957 and 1958, but to send men would require launch power and reliability as yet undeveloped, and scientists around the space effort could come to no agreement as to whether man could function or even survive the zero-gravity space environment. Some predicted that the heart would race, others that it would stop; that the astronaut would not sleep, or would sleep continuously; that he would be euphoric or depressed.

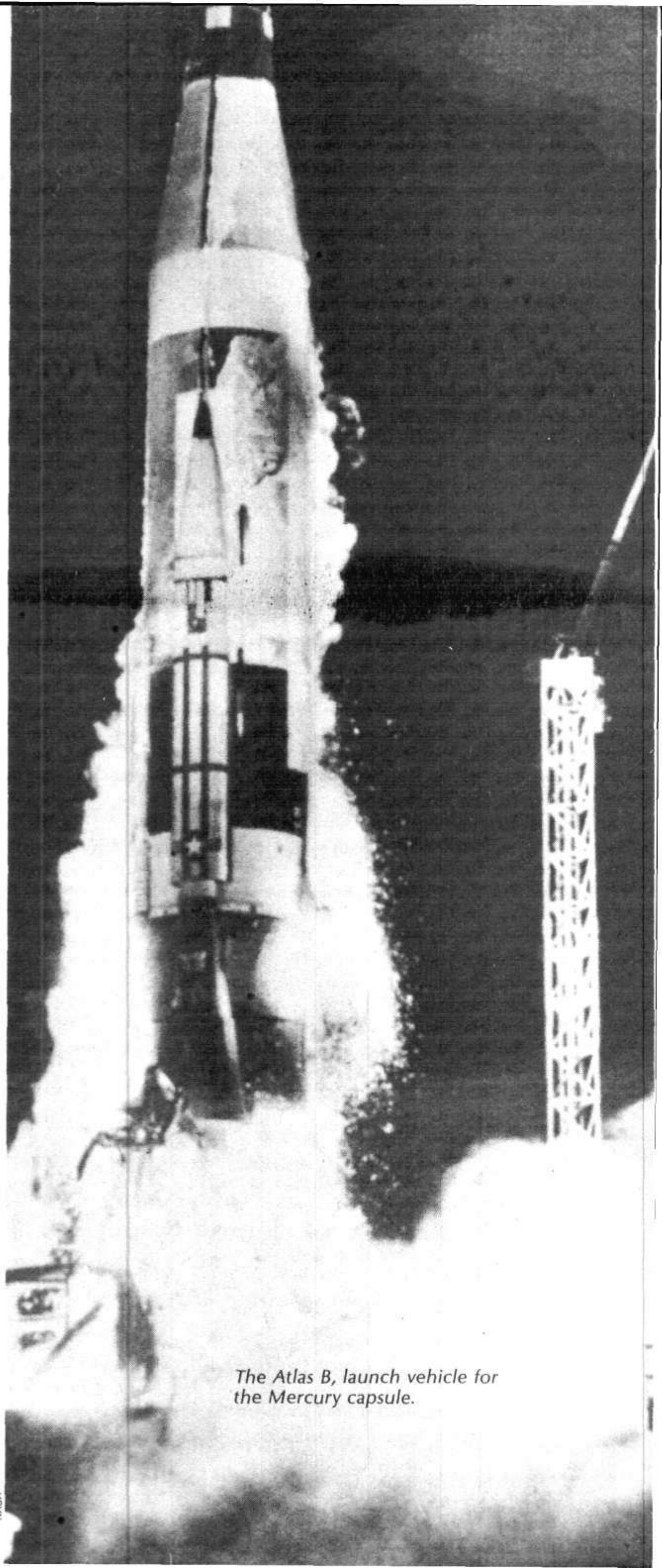
But when the Soviets launched a dog into space aboard Sputnik 2 on Nov. 3, 1957, and it survived the uncertain journey, scientists became confident that man could survive the space environment.

By March 1958, the Eisenhower administration decided to go ahead with a large-scale civilian space program. On July 29, the President signed the law creating the National Aeronautics and Space Administration and NASA administrator T. Keith Glennan gave the green light to Project Mercury—the first U.S. manned space program.

NASA's first 10-year plan, beginning in 1960, included every aspect of research and exploration to get man into space: a manned program starting with Earth orbitals and leading to circumlunar flight; scientific satellites to study the near-space environment; lunar probes to measure the Moon's characteristics and take photographs; planetary probes to Mars and Venus; weather satellites; and the development of larger launch vehicles to carry man beyond the Earth.

Building the Ships

The technology for getting into space was at best primitive at the beginning of the Mercury program. In 1959, the United States attempted 37 satellites launches, but



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The Atlas B, launch vehicle for the Mercury capsule.

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The Russian dog Laika, who went up in Sputnik 2 in November 1957. Monkeynaut Baker (below), the first animal to survive an American space flight, made a suborbital journey in May 1959. Baker now lives at the Alabama Space and Rocket Center in Huntsville.

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fewer than one third obtained orbit. The aerospace and electronics industry had to rethink the reliability of their hardware, and NASA began to institute testing and redundancy programs to make the spacecraft safe for human beings.

Like every manned program prior to the Space Shuttle, the Mercury capsule and its launch vehicle, the Atlas rocket, were flight tested unmanned. In September 1961, the Mercury-Atlas combination was orbited successfully and landed on target, east of Bermuda. On Nov. 29, 1961, the final test took chimpanzee Enos on a two-orbit ride, landing him in good health. Finally, on Feb. 20, 1962, John Glenn became the first American to orbit the Earth, completing three Earth circlings.

The Mercury program was an unqualified success, brought to a spectacular close in 1963 with astronaut L. Gordon Cooper's 22-orbit flight—a trip that far surpassed the design limits of the spacecraft.

Explorers and Pioneers

While the engineers and astronauts were making certain that man could sustain the space environment for at least brief periods of time, and that spacecraft could be designed to support him and provide an in-space environment for scientific work and exploration, scientists were still trying to find the answers to some basic questions before man could be sent into the vast unknown beyond the protective atmosphere of the Earth.

When Explorer I returned from its maiden flight in January 1958, Dr. James Van Allen examined the radiation counter he had placed in the satellite. It had been radiation-saturated at about 965 kilometers above the Earth, indicating a dense ring of radiation that came to be known as the Van Allen belt. Would this damage the spacecraft and men inside if they ventured out into space?

There had been much speculation about the radiation in interplanetary space, the charged particles that are emitted periodically from the Sun, and there were even questions about whether there were small rocks or asteroids that would prove to be an obstacle to space flight.

To probe the unknown space environment NASA sent out "Pioneer," a series of satellites that took various measurements and sent them back to scientists on Earth. Pioneer 5, launched on March 11, 1960, explored the interplanetary space between the Earth and Venus and provided some of the first data on radiation in space. The Pioneer series of the 1960s discovered Earth's magnetosphere, measured the effects of the solar wind, observed tongues of plasma spewed forth from the Sun, and measured the interplanetary magnetic fields.

Even after President Kennedy declared the manned landing on the Moon a national priority on May 25, 1961, NASA had its sights set on exploration, probes, and eventual colonization of the Moon and nearby planets.

The first planetary fly-by took place in December 1962, when Mariner 2 passed within 34,400 km of Venus. Mariner 4 flew past Mars on July 14, 1965 and sent back the information that Mars has no magnetic field nor radiation belts, but has a thin atmosphere. In 1969, Mariners 6 and 7 flew as close as 3,200 km from Mars. Over their lifetimes, the Mariner crafts took 198 high-quality television photographs of the red planet, and sent back pictures in the ultraviolet and infrared spectra of the atmosphere and surface. Then, in 1971-72, Mariner 9 became the first spacecraft to orbit another planet.

The Mariner series continued to do reconnaissance exploration of the planet Venus as well. Mariner 5 flew past Venus on Oct. 19, 1967. Mariner 10, launched in November 1973, flew by Venus and continued on—for the first time—to the hot, barren planet Mercury, which it circled three times.

Scientists were very concerned about landing a man on the Moon. Many believed that the lunar surface might consist of a thick layer of dust into which a ship might land and disappear without a trace. Storms and other occurrences might also make a landing hazardous.

Before NASA could even contemplate sending men to the Moon, unmanned explorers would have to measure, map, and photograph Earth's nearest celestial neighbor, much as parties of explorers mapped out and prepared the way for the first group of colonists to the New World.

A series of Ranger probes, therefore, were sent to the Moon, followed by the Surveyor landers. Ranger orbited the Moon, taking a set of photographs that were 2,000 times more detailed than those from Earth. Then, like the Galileo mission that NASA hopes to send to Jupiter in the 1980s, Ranger photographed the Moon's surface as it concluded its mission by falling to impact there. Ranger took photographs as close as 6 km from the lunar surface, 2.3 seconds before it crashed, dispelling the scare stories about disappearing into the dust.

Between 1966 and 1968, Surveyor probes performed the first soft lunar landings, while a lunar orbiter photographed 90 percent of the Moon's surface to select potential Apollo landing sites.

After more than a half-dozen soft landings and a near-complete map of both the "dark" and "light" sides of the Moon, NASA was ready to mark the map for a manned expedition to the Moon.

To the Outer Planets

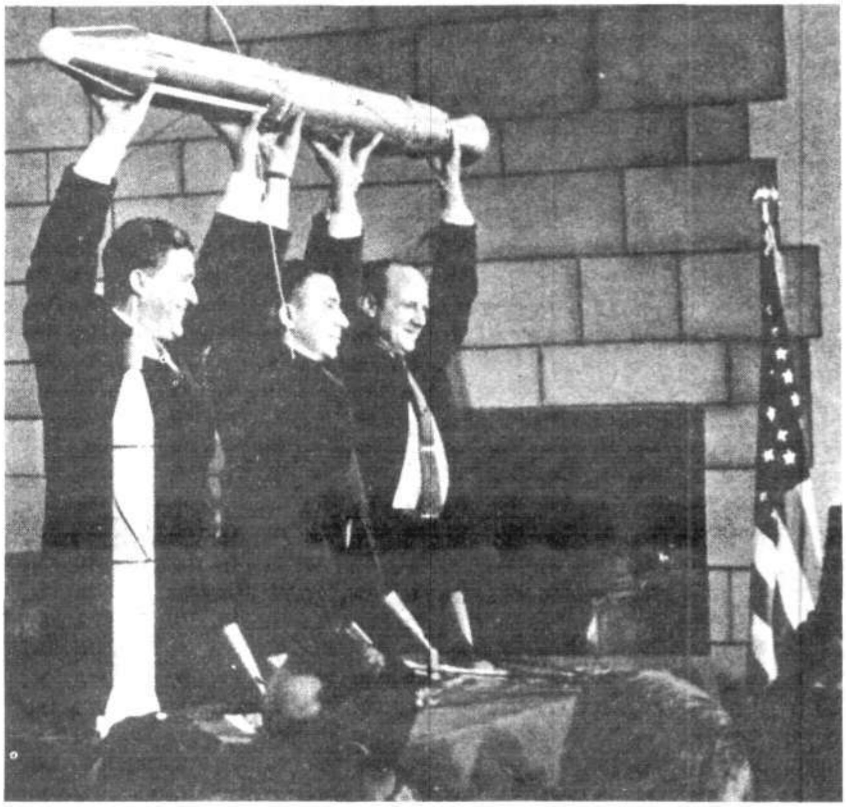
As part of the unmanned exploration required for colonization beyond the Moon, at the end of the 1960s NASA and U.S. scientists were hoping to carry out a project known as the Grand Tour of the Solar System. The plan was to take advantage of a once-every-175-year phenomenon—the orbital line-up, or conjunction, of the five planets beyond Mars. An unmanned spacecraft launched in the 1970s would have passed by each of the other planets as it moved toward conjunction, reaching the last one in 1982.

The small satellites that had proved their versatile capabilities in the 1960s were directed out past the near planets in the 1970s. The shining successes of the past decade were the spectacular views of these faraway worlds that man can only faintly perceive through Earth-based telescopes.

Pioneer 10, launched on March 2, 1972, achieved the highest velocity every obtained—51,200 km per hour—and hurled itself through the asteroid belt between Mars and Jupiter for the first time. Pioneer 10 and its successor, Pioneer 11, sent back magnificent pictures of the giant Jupiter, unobstructed by the filtering atmosphere of Earth.

Pioneer 11 continued past Jupiter and arrived at Saturn in August 1979 to show the world its first glimpse of the ringed planet. The Voyager spacecrafts, although scaled down from the initial plan, were set on their journeys in 1977 to encounter both Jupiter and Saturn from closer distances, from different angles, and with more sophisticated equipment than their smaller Pioneer predecessors.

While Voyager probed the outer planets, Viking sent two orbiters to Mars and soft-landed on the red planet in an exploratory step for a manned mission to Mars. The original mission for Viking involved a large spacecraft to carry an entry capsule through the Martian atmosphere. That would have been a preparatory step for a manned landing.



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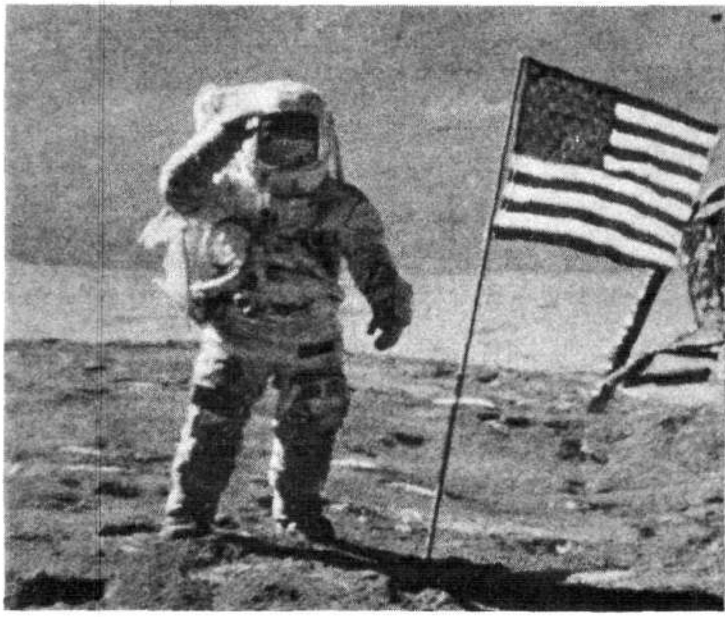
A duplicate of Explorer 1, the first American satellite to orbit the Earth, is held aloft in triumph Jan. 31, 1958 by (from left) Wernher von Braun of the Army Ballistic Missile Agency, James Van Allen of the State University of Iowa, and William H. Pickering of the Jet Propulsion Lab.

PART II

I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth. No single space project in this period will be more impressive to mankind, or more important for the long-range exploration of space; and none will be so difficult or expensive to accomplish.

—President John F. Kennedy,
May 25, 1961, Special Message to the Congress on Urgent National Needs



Manned Space Exploration: Projects Gemini and Apollo

Reasonably sure that man could survive the eight days it would take to travel to the Moon and back, the teams of researchers and builders at NASA faced the challenging task of designing and constructing the machines that would carry their astronauts safely.

When NASA began the design work for a lunar mission in the late 1950s, most thought the first manned flight would not occur before the decade of the 1970s. The announcement by President Kennedy on May 25, 1961 that the nation's goal was now to complete such a mission by the end of the 1960s accelerated the decision-making process at NASA.

On Jan. 3, 1962, NASA announced a series of manned missions, called Project Gemini, to bridge the technology gap from simple Earth orbit to the complex machines and maneuvers needed for the Apollo program. Apollo would be the most complex set of tasks man had yet undertaken, and each step had to be tested individually before the full mission was ready to fly.

NASA had decided that to achieve the lunar mission, the space program would integrate two three-stage space vehicles. The launch vehicle, the Saturn 5 rocket, would be a cluster of five engines, arranged in three stages: The first and second would propel the astronauts into Earth orbit, and the third would propel them out of the Earth's gravitational pull, pushing them on their way to the Moon.

The spacecraft was also designed as a three-stage machine. (1) The Command Module would carry the three-man team into lunar orbit. (2) A Service Module behind the Command Module would carry the fuel and engines for propulsion to maneuver the Command Module into its proper lunar orbit and to get the Command Module back to Earth. (3) A two-stage Lunar Module would carry two of the three astronauts to a soft lunar landing. After finishing their work on the surface of the Moon, the upper stage of the Lunar Module would be separated and would bring the astronauts back up to the orbiting Command Module.

Project Gemini Begins

The goal of the Gemini program was to develop the technology for two spacecraft to rendezvous in space, to propel a spaceship out of the Earth's gravitational pull, and to demonstrate man's ability to work in the zero-gravity space environment.

The Mercury capsule was scaled up to accommodate two astronauts, and the changes and improvements in the Gemini capsule were later used to assist the Apollo design work.

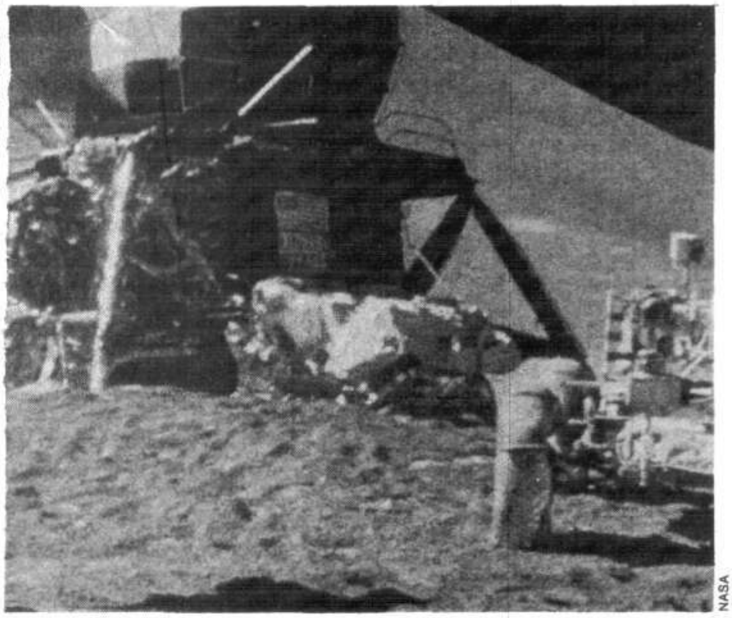
On April 8, 1961, Gemini 1 lifted off, unmanned, and the success of the launch vehicle/spacecraft design was confirmed.

When Gemini 2 was finally launched in January 1965 after several delays, the 19-minute unmanned flight confirmed the readiness of the fully equipped Gemini spacecraft and the integrity of the heat shielding during reentry. Gemini was now man-rated.

The final test flight was conducted on March 23, 1965, a three-orbit qualification test.

In early June, Gemini 4 stayed aloft for four days. The next craft, Gemini 5, doubled this to eight days, surpassing the long-duration test record set by the Soviets. Next, Gemini 7 spent fourteen days in space with the encouraging medical news that no long-term effects of weightlessness seemed likely to interfere with the planned Apollo mission.

NASA's next objective was to begin the delicate ren-



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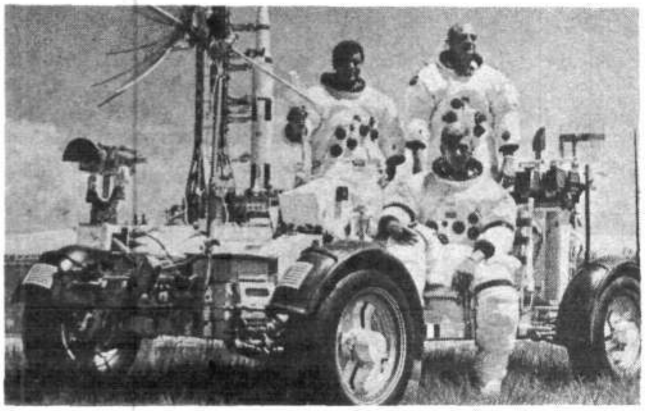
At left, astronaut Jim Irwin, Apollo 15, salutes the flag at Hadley Base on the Moon. Below, the crew of Apollo 17 poses in a Lunar Rover: (from left) Harrison Schmitt, lunar module pilot; Ronald E. Evans, command module pilot; Eugene A. Cernan, commander.



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dezvous and docking maneuvers. Gemini 8 docked successfully with an Agena target and then used the docked Agena engine to boost the spaceship into a higher orbit. Gemini went 1,372 km above the Earth, past the radiation belts named for Van Allen, and demonstrated by docking with a passive target (the unmanned Agena) the feasibility of rendezvous with a passive satellite for repair work in space.

Man Works in Space

But getting there, rendezvousing, and docking were just part of the job. Since man had to be able to do useful work once on the Moon, mainly scientific experiments and exploration, the ability to perform extravehicular activity (EVA) tasks outside the protective Command Module had to be proven before Project Gemini could be declared a success.

This happened on June 3, 1965, when astronaut Ed White performed the first extravehicular activity, attached by a tether outside the Gemini 4 craft.

The last seven Gemini flights concentrated on testing and developing the guidance and aerodynamic systems for pinpoint landings back on Earth. As the mission concluded, Gemini had demonstrated that man could withstand weightlessness for at least two weeks, that man could do work in space, and that the technology that was being designed and built by more than 400,000 people on Earth could perform safely in space.

To the Moon: Project Apollo

During 1964 and 1965, the new clustered-engine Saturn rockets were tested, six with a new second stage of liquid hydrogen. By the end of 1966, the Saturn 1B and the Block 1 Apollo Command and Service Modules were considered man-rated. On Jan. 27, 1967, the first manned Apollo spacecraft was on the launch pad and astronauts Grissom, White, and Chafee were going through the countdown of a simulated launch. At T-minus-10 minutes, the crew reported a fire aboard the spacecraft; when the hatch was opened 5 minutes later, all three had suffocated.

For the next 18 months, NASA engineers and U.S. industry redesigned the entire module, replacing the miles of electrical wiring with fire-resistant materials. Meanwhile, the unmanned test flights continued.

Apollo 4, launched Nov. 9, 1967, was an unmanned test of the Saturn 5 rocket, which stood 110 meters high, counting the three-stage launch vehicle and the spacecraft. The first stage took the Apollo into Earth orbit; the third stage simulated a lunar trajectory, taking the Command Module 17,335 km into space.

After a final unmanned test on April 4, 1968, the new Saturn 5 was qualified man-rated.

Now came the crucial test.

Apollo 8 was launched on Dec. 21, 1967, and on Dec. 23, the crew became the first human beings to pass out of Earth's gravitational control into the pull of another body. On Christmas Eve the astronauts read from Genesis and sent holiday greetings back to Earth. The Service Module had been fired to slow the Apollo craft down for lunar orbit, and as they circled the Moon the astronauts became the first men to see its dark side.

Apollo 9, launched in March 1969, practiced the docking of the Command Module and the Lunar Module while in Earth orbit. In May, Apollo 10 reached lunar orbit, and the Lunar Module was separated from the Command Module configuration. The Lunar Module descended to within 14 km of the Moon, ascended, and docked with the Command Module.

The world was breathless. Estimates are that one fifth of the world's population watched the Apollo 11 astronauts lift off from Cape Canaveral on July 16, 1969 and watched them step onto the Moon four days later.

President Kennedy had set the United States the goal of reaching the Moon within a decade, and NASA had met it—ahead of schedule. At a total cost of $23.5 billion for a project that spanned 11.5 years and landed 12 men on the Moon, Project Apollo and its predecessors demonstrated conclusively what the nation could accomplish with the wholehearted backing of the President, the Congress, and the American people.

Getting the U.S. Back into Space

In this exclusive interview with Fusion, *Space Shuttle Pilot Capt. Robert Crippen talks about the flight, where he thinks NASA is going, and what an accelerated space program would mean for the nation's youth. The full interview appears in the August 1981 issue of* Fusion.

Asking the questions is Fusion's *Marsha Freeman, who watched the launch in person at Cape Canaveral and who frequently writes about the space program.*

Fusion *is proud to claim Capt. Crippen as a regular reader.*

Crippen does acrobatics in zero gravity. NASA

Question: From your sense of working in the program and actually flying the plane, could you give us an idea of what you think of the program and its potential?

Actually, what I would say about the Shuttle and what it has opened up for us is what I was saying prior to doing the flight. It proved that it could do everything we said it could do, at least to this point in testing. We still need to complete all the other test flights that we have outlined in the program, and these are very important to us to ensure that we understand its full operating capability. But the main thing it will do for us is get us in and out of space easily.

Some people refer to it as a space truck, both derogatorily and, in my opinion, not derogatorily. That's what it is—it's a truck.

But it's important to us from many viewpoints, starting from the scientific standpoint. It is important to us from the standpoint of science: being able to get out and study the environment of space and also to study our own environment back here on Earth. It is important from the standpoint of being able to exploit space for manufacturing, and your magazine has done a good job of exploring for us the things we can do while we're out using the vacuum and weightless environment. It's important to us from the standpoint of communications, weather satellites, and what have you, because we can build the satellites more cheaply and we can also put ourselves in a position to repair satellites.

And the military aspects of it—even being a military manned station down here we don't deal directly in the DOD [Department of Defense] things. All we're planning on doing right now is being able to carry them [DOD things]. The DOD is a heavy user of space already. It's proven very beneficial to them and that's just one of the reasons that the DOD was a big supporter of the Shuttle. They need to utilize it and they want to do it as economically as possible because they work under tight budget constraints, the same as we do.

Just the fact that we have opened up space to get into and out of easily, that's really the prime thing.

Question: One of the areas that we have been most interested in is the contributions of NASA in education. About four months ago we began publishing a children's science magazine called The Young Scientist, geared to junior high school youth. Have you given any thought to the kind of role that a more invigorated space program might play over the next decade in upgrading all our science education programs?

. . . I still think that we have fairly important and good scientific and engineering development in our education, all the way from grammar school on up. It is also true, I believe, that the general trend of education has seemed like we're not producing the same caliber of students on an overall level. I'm not sure exactly what the reason for that is. I think if we knew what the reason is, we'd go solve it.

I know from the standpoint of the military, quite often when we go out and recruit people who are high school graduates, you would anticipate that they have a certain caliber and knowledge. At least they ought to be able to read training manuals, but we've had problems with that.

I think that getting back into space and getting the economy going on a scientific note creates jobs, and people want to fill those jobs, and that is going to stimulate the educational system to make people smart enough to fill them.

I was a sophomore in college when Sputnik was first

Space Shuttle *Columbia* astronauts John Young and Robert Crippen getting ready for the Shuttle's maiden flight.

put up, and that was certainly when we got a lot of furor about what the educational system was doing in this country—could it produce the same level of scientists and technical capabilities as the Soviets were doing? As far as I'm concerned, we can easily do that without even trying, but we can do much better. I believe that any time we've got scientific programs such as going into space that are viable, we've got to create jobs and we've got to create education. It's a natural by-product. . . .

Science is very fundamental to our nation, and so is technology. It is important that we continue to have people that stress those areas at all levels, from the man on the street all the way up to the people who run the country. As long as we have people and organizations like yours that focus on those particular areas, I think that we can keep that drive that we need. I appreciate the kinds of folks who do that. . . .

The main thing that I've always tried to orient young people to is to latch on to something that they enjoy. It may not be necessarily what your parents want you to enjoy, but if it's something you really enjoy, and if you work hard at it, you'll be successful. I think that's the main thing that I've always tried to convey to kids.

I think that the Shuttle did give a sense of pride to the country and a feeling that we can accomplish something that we set out to do.

Question: I'd like to ask you where you think the space program should be going over the next 20 years.

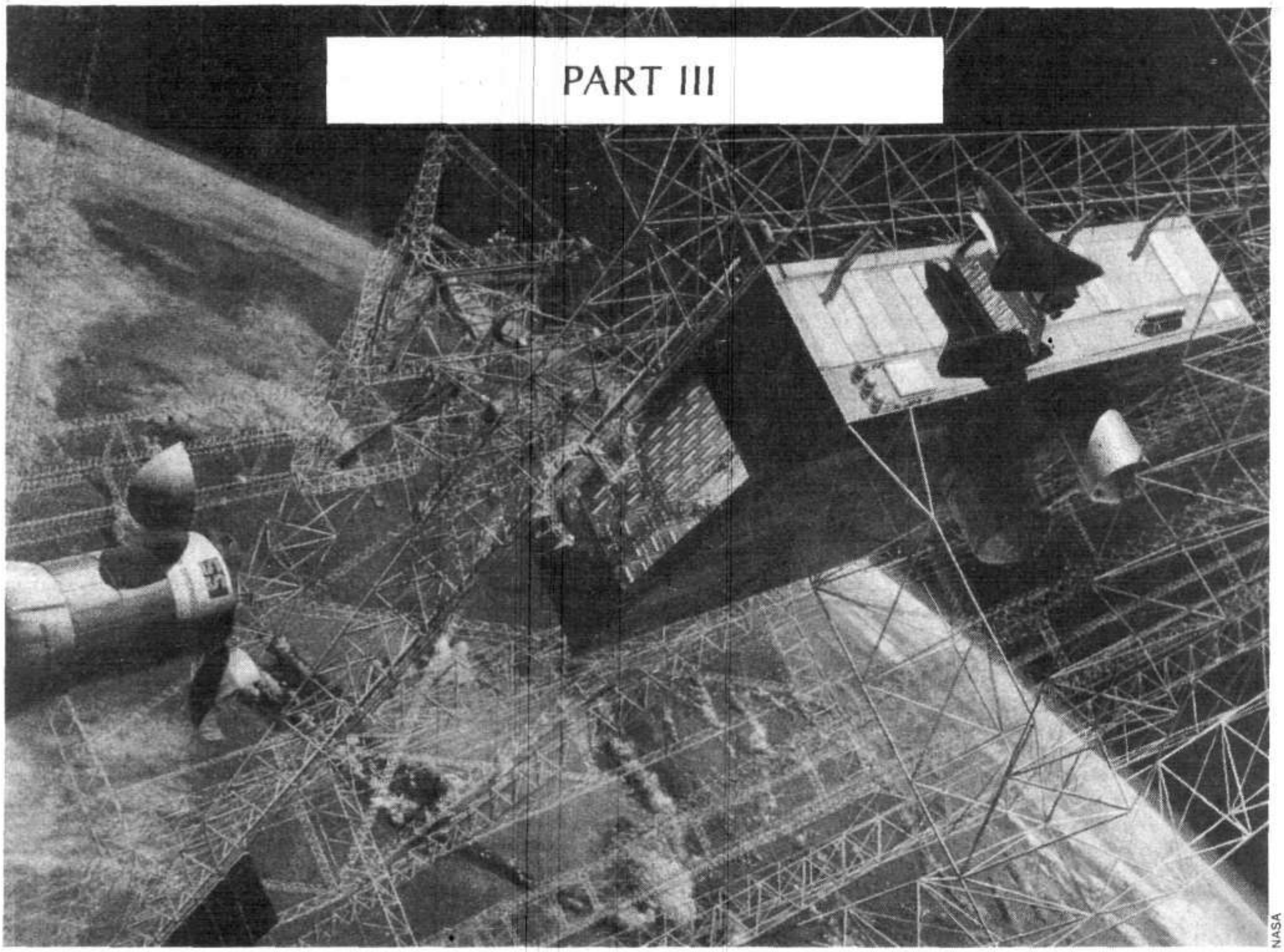
One of the things that Senator Schmitt, myself, John Young, my boss Chris Kraft at the Johnson Space Center here, and a large number of other people feel very strongly about is that we need to put a United States man and woman in space permanently. Our goal that we would like to proceed on in that direction, which looks like the best, is what we're calling a Space Operations Center. That's a fancy name for a permanently orbiting manned satellite that will allow us to explore some of the manufacturing things that we talked about, some of the scientific things, and also, one that we feel is very important, seeing how we can develop using solar energy from outer space and beaming it back to Earth. We think there is a large amount of potential in that particular area.

We would like to get the go-ahead from the administration and start working on such projects very soon. In fact, John and I, when we get the opportunity to go to Washington, plan on trying to make that point very heavily both to the administration and to the Congress. I guess I would like to see that done in parallel with continuing to utilize the Shuttle not only to build that space station but to see it really put to work getting satellites up.

We want to get the Shuttle operational, where it's like an airline kind of operation. In parallel with that, we would like to put up some kind of permanently orbiting space station. It would take quite a bit of time, but certainly in the next decade we could have something going of that nature—if we could get that kind of financing.

Beyond that, we hope to go back to the Moon, but before we go back to the Moon, we want to be in a position so that when we get there we could put up a colony that would allow people to stay up there for extended periods of time. I expect to see us colonize the Moon and, eventually, travel out beyond. We'll get a trip to Mars some day. Unfortunately, I don't think it will be while I'm flying.

PART III



NASA

Colonization: The Future in Space

On the very day in 1969 that Apollo 11 left the Earth to land the first men on the Moon, Vice-President Spiro Agnew called for a national commitment to place men on Mars before the end of the century. A Space Task Group chaired by the Vice-President submitted a report to President Nixon on Sept. 15, 1969, making recommendations for the next 10 years in space. Three options were proposed:

Option one included a lunar-orbital station, an attendant Earth-orbital station, and a planned lunar base in the 1980s that would serve as the stepping-stone to Mars. The second option focused on a manned Mars mission in 1986. A third, known as the Space Transportation System, or STS, consisted of a space shuttle to carry men and equipment up to a 100-mile high parking orbit, an orbital transfer vehicle (or space tug), and a manned space station.

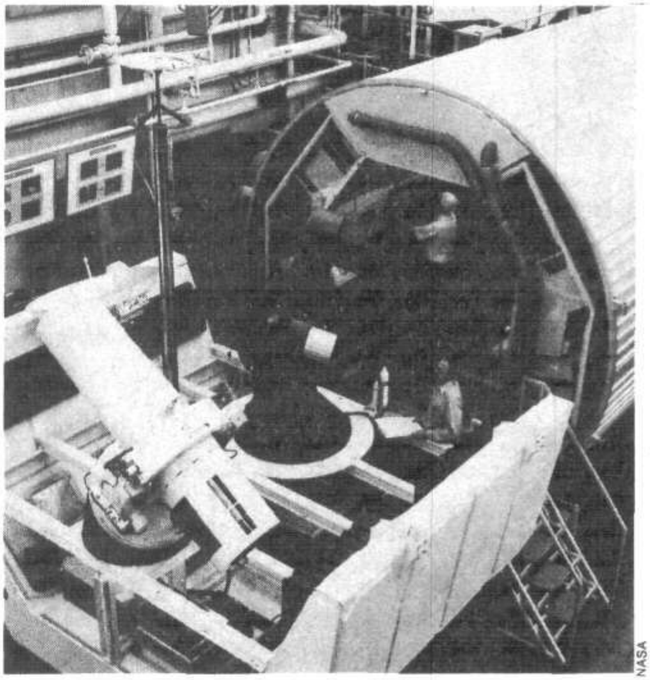
The STS was the only manned program to survive the cuts of then Office of Management and Budget director Caspar "Cap the Knife" Weinberger. However, the Shuttle that exhilarated America in April 1981 was only one piece of the three-part Space Transportation System as originally conceived. To realize the Shuttle's full potential, and to put America back on the path to space colonization, the other key links in the STS must be brought back on line.

The first part of the STS package to succumb to the budgetary knife was the manned space station. It was to be a center for space research, as well as an operations center for manned space flight activities. To save more money, the Shuttle itself was redesigned, eliminating the recoverable booster. Instead, the Shuttle was launched attached to an expendable tank, assisted by two recoverable solid rocket boosters. But this was not enough savings, and so the "space tug," the orbital transfer vehicle, was put on ice presumably to be brought back after the Shuttle was developed.

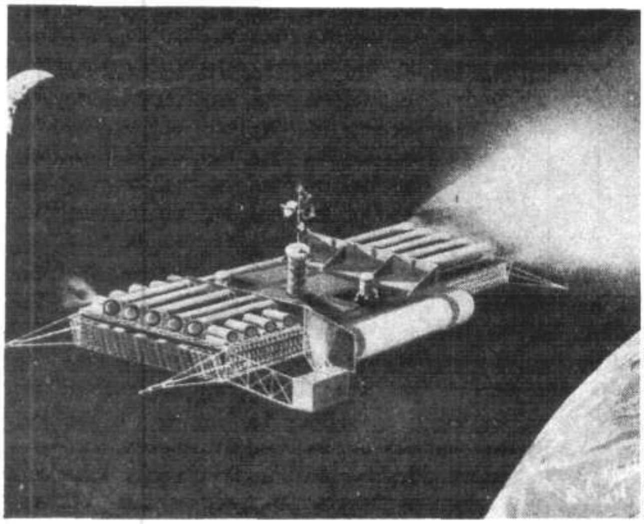
Although accomplishments were made, the decade of the 1970s left America not much closer to fulfillment of the goal of colonization than the day in 1969 that Apollo landed the first men on lunar soil. How did it happen? How was the hope of a generation put on "hold" for an entire decade?

It is no mere change in the nation's climate, a shift in political winds, that explains this turnaround. Rather, definable political forces were at work deliberately planning the end of the space program.

Already in July 1958, before the ink was dry on the



NASA



Courtesy of Dr. Krafft A. Ehricke

At left, the Space Shuttle opens the way for colonization. Here, an artist's depiction of a manned Space Operations Center and freight transfer terminal. Above, technicians load the first payload to be carried into space by the Space Shuttle into a cargo integration equipment stand that simulates the orbiter's cargo bay for testing. The payload, OSTA-1, will carry experiments on earth resources applications in the second Space Shuttle mission. Above right, Krafft A. Ehricke's depiction of a cislunar superfreighter.

Space Act that created NASA, the University of Michigan's Institute for Social Research, the Brookings Institution, and the British-based Tavistock Institute were presenting studies to Congress in an appeal for consideration of the "social effects" of the space program. This was no philanthropic effort. Concentrated in these "social science" think tanks were the leadership and controlling core of the movement that was to be unleashed in full force over a decade later to become today's antitechnology environmentalist shock troops against science and human progress.

In a March 1961 Brookings report, "Proposed Studies on the Implications of Peaceful Space Activities for Human Affairs," author Donald Michael, who a few years later became a member of the zero-growth U.S. Committee for the Club of Rome, began the argument for limited resources:

> Even among scientists in the space community . . . there is some concern as to whether an "all-out" space effort is in the best interests of science and the nation. While this concern is related in part to the anticipated costs of space activities, there is also a feeling that continued excessive attention to space may blind the policymakers to the compelling needs and opportunities in other physical and social sciences.

To ensure that any potential for disagreement would be promoted, Michael proposed as an area for "study" the "disillusionment and cynicism" among NASA scientists, who feel they are "being used by the politicians."

But at that time in our history, the antitechnology advocates were still regarded by our nation's leaders as the fringe kooks that they are.

The space effort moved boldly forward in the early 1960s, driving the zero-growth faction to distress. By the middle of the decade, the Tavistock Institute's journal *Human Relations* was reporting that the U.S. space program was producing an extraordinary number of "redundant and supernumerary" scientists and engineers. "There will soon be two scientists for every man, woman, and dog in the society," a related report wrote.

These new scientists and engineers had the nasty propensity of reproducing themselves at a rate much faster than any other segment of society, lamented Tavistock. Their very presence and rate of expansion had a profound impact on the values of the entire American population from skilled workers and office clerks, down to grammar school children eager to explain to anyone who would listen all the secrets of rocket propulsion from construction, fueling, and liftoff, all the way to reentry and retrieval procedures.

The Tavistock report was a call to arms. Soon after, the high-level forces—the same foundations, corporations, and families who today fund and control the environmentalist-terrorist groups—began to move.

At a summer 1968 meeting in Bellagio, Italy, Aurelio Peccei, who later became the leader of the rabidly antigrowth Club of Rome, met with an international collection of experts dedicated to the destruction of science and the bringing on of the "postindustrial society." In a final Bellagio Declaration, Peccei and his experts attacked "blind reliance on science" and called for "the modification of the very structure of the human systems."

Their prime target was the U.S. National Aeronautics and Space Administration.[1]

The lack of an orbital transfer vehicle and a space station is now the principal obstacle to further development of the U.S. space effort, and has set us back a full decade in reaching our goal.

Studies now under way at the Johnson Space Center are pinning down plans for a manned Space Operations Center (SOC) that could be launched by the Shuttle by the end of the 1980s. The cost would be $2 billion to $3 billion. The SOC would serve as a base for expansion of manned space activities. It would be a center for in-space repairs of satellites, a launching point for higher-orbit satellites and interplanetary spacecraft, and a construction base for large space platforms.

The space tug, or OTV, is an essential partner to the manned Space Operations Center. A manned reusable OTV as originally conceived would carry out such important tasks as satellite retrieval and launch assistance to interplanetary payloads. Current plans for the Shuttle involve the launching of communications and other geosynchronous satellites by means of nonreusable booster rockets. Although the satellites can be sent up this way, they cannot be brought back. Taking into account the loss of satellites that may need only simple repair and the cost of the expendable rockets to launch them, the reusable OTV becomes an economical proposition in a short time.

One early commercial mission proposed for the space station and OTV is to construct a large antenna array in space (where the zero gravity makes such projects far easier than on Earth) that the OTV would carry up to synchronous orbit. (At 22,300 miles altitude, a satellite revolves at a speed equivalent to the Earth's rotation, keeping it constantly above the same point. Communications, navigation, and spy satellites thus use the so-called synchronous orbit.) The large antenna setup would take the place of numerous communications satellites, easing overcrowding and cheapening maintenance.

The Promise of the Shuttle

In the larger scheme, the importance of Apollo was not merely that it achieved a stunning success in man's venture into space but that it kept alive the pursuit of science and development of new technology.

The same is true of the Shuttle.

The Space Shuttle will make U.S. space travel an everyday occurrence, much like a scheduled airline. It will take U.S. scientists who have not trained as astronauts into space for the first time, and it will give us the ability to do many things in space we could not do before. With an operational shuttle system, for example, satellites and other craft already in space could be repaired, refurbished, outfitted with new scientific instruments, and their completed experiments could be brought back to Earth. The Shuttle has a ready market for such services now. The Spacelab module for the Shuttle payload bay, now being built by the European Space Agency, will provide the United States and other countries with a returnable laboratory that will be continuously changed and upgraded for successive trips. The scientists will work in a shirtsleeve environment without bulky space suits and perform varied experiments in the zero-gravity of space.

The uses of the Shuttle itself are endless; but most important, it provides us with the jumping-off point for the stars. It can be used to build large structures in space, or with later designs, on other heavenly bodies. It will allow us to live in space the way the railroad allowed Americans to spread across a continent.

The Shuttle has reawakened an excitement in our young people that there are frontiers yet to cross. It has put NASA and the nation's scientists and engineers back in the public view as a sector of our national economy that represents growth and accomplishment. Now, and for the next 20 years in space, man must develop the propulsion techniques and industrial base on the Earth to reach for the stars.

Industrializing Space

With the development of fusion propulsion systems, manned flight to distant planets will become practical, and man can begin to take advantage of valuable metals and minerals that can be mined from other planets. Chemical propulsion, adequate for escaping the Earth's gravity, does not permit travel to Mars, for example, in a time less than years. Fusion propulsion, with its larger energy density and higher combustion temperature, will provide an exhaust velocity of a few thousand kilometers per second (as opposed to 10 to 20 kilometers per second for chemical propulsion), making the trip to Mars possible in weeks. In addition, as described in detail by Dr. Friedwardt Winterberg,[2] a fusion space rocket, assembled in orbit, could carry a payload of thousands or even millions of tons—enough for the necessary equipment for industrialization.

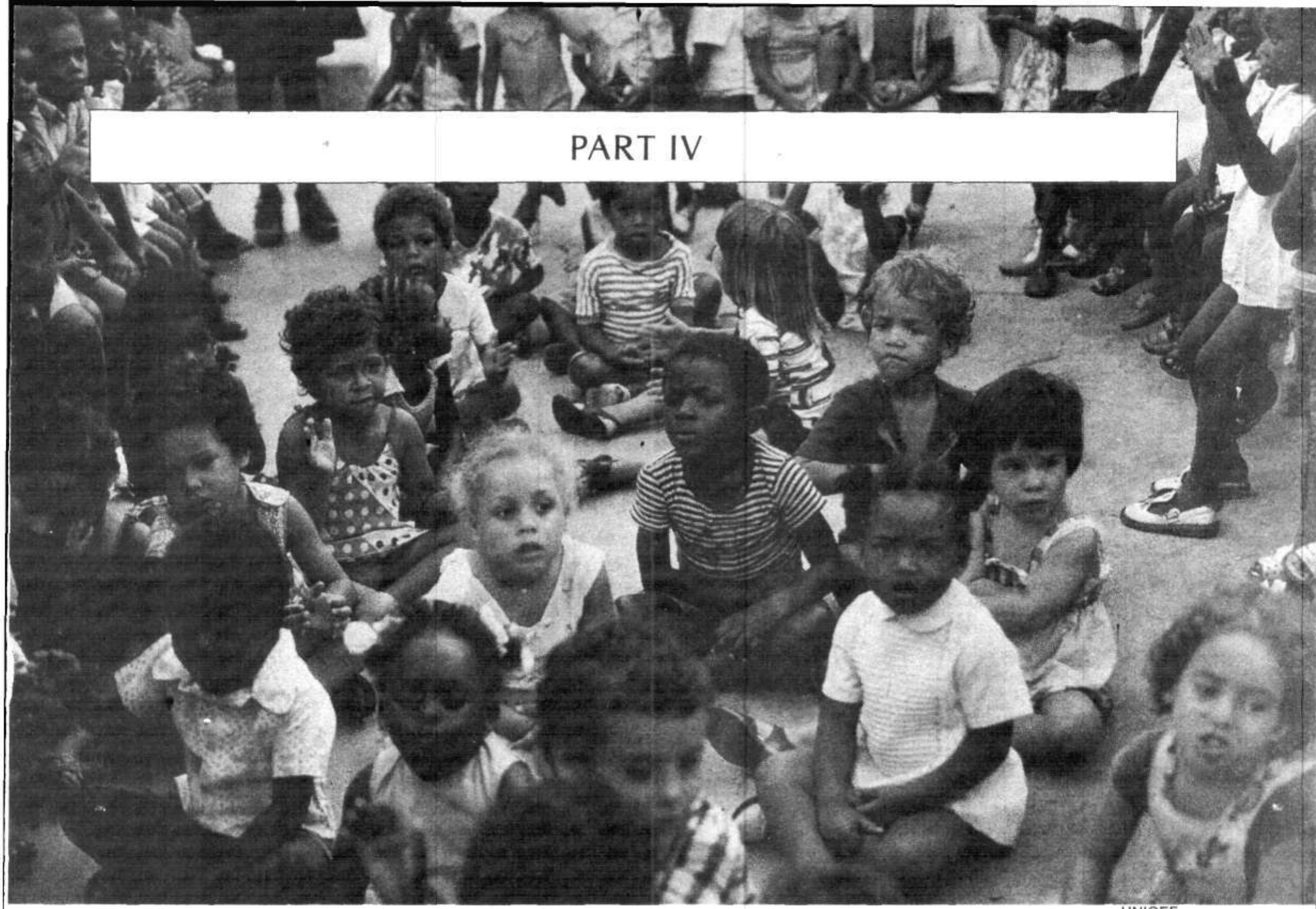
Detailed proposals on mining the Moon have been put forward by another space pioneer, Dr. Krafft Ehricke, whose book on industrializing the Moon will be published shortly. As Ehricke writes:

> Lunar industries offer the option of separating production elsewhere from consumption on Earth. This is an important feature in an industrial civilization, where it becomes increasingly difficult to do both indefinitely in the terrestrial environment only. The Moon is a space industrial sister ship of the luxury liner Earth. Its proximity makes it Earth's seventh continent. It provides needed raw materials. It offers an environment in which important new advances in technology, especially nuclear technology, can be utilized extensively for human benefit outside the biosphere, enabling the Moon not only to become a vast industrial complex but a source of food, a place on which to settle in large numbers, and a springboard for extensive cultivation of other worlds in this solar system.

Truly, with the development of fusion propulsion and an aggressive NASA space program, not just the Earth but the stars also will be man's garden.

Notes

1. See *Fusion*, Sept. 1980, "The NASA Story" and "The NATO Plan to Kill U.S. Science."
2. See *Fusion*, April 1981, "Colonizing Space with Fusion Propulsion."



UNICEF

A World Population Big Enough to Support Colonization

A successful plan for exploration and colonization of any new world must include a way to expand the mother country supporting that exploration. Exploration and colonization of space, for example, can never work as an escape valve for the Earth; it can work only as an integral part of continued growth and development of Earth's economy.

Think of Queen Isabella on Columbus's departure for the West—the new frontier of the 15th century. She might have put it this way to her explorers: "Spain must carry the torch of civilization westward. As the Atlantic outpost of European humanism, this is our responsibility. But we are too small and weak in our present state. We must grow if we are to successfully civilize the West. I have a vision of a Spanish new world whose future is tied to ours. We can grow if our exploration brings not gold to Spain, but progress. New people, new ideas, new markets, and new raw materials are what we seek in the West."

The Spanish colonizers did not carry out this strategy, and the result was a collapse of the effort in less than 100 years—not because the American gold was exhausted, but because Spain did not develop.

Today's space program must have the same strategic conception: The solar system is our new world, space our new ocean; and to successfully explore and colonize the solar system requires that the exploration itself result in the development of the old world, Mother Earth.

This development requires the most extensive use of advanced technology possible, limited only by our ability to train the workforce capable of using this advanced technology. In the 1980s this means nuclear energy and its associated technologies. Nuclear energy for electricity, for steel making, and for fertilizer and chemical production is an essential ingredient in the codevelopment of Earth and space. These technologies can be the basis for the *rapid industrialization of the entire Earth*, as well as the basis for a terrestrial economy large enough to support the industrialization of the solar system.[1]

Looking slightly farther into the future, there is a differ-

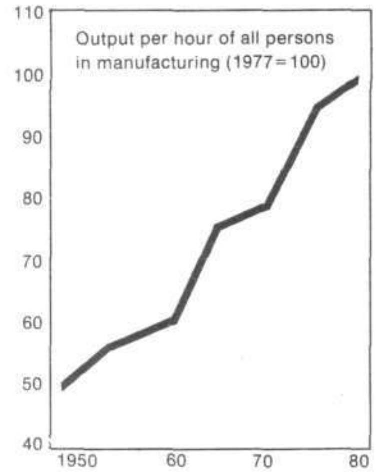


Figure 1
PRODUCTIVITY GROWTH IN THE U.S. ECONOMY

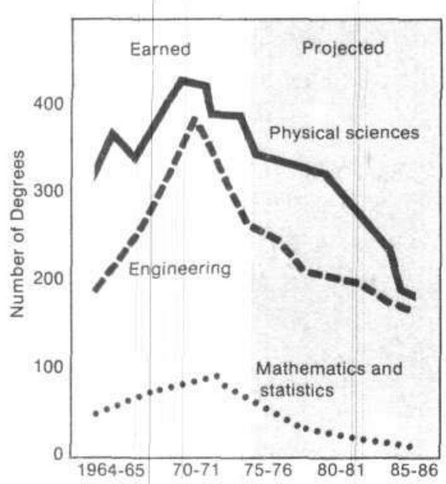


Figure 2
EARNED AND PROJECTED PHd's IN SCIENTIFIC FIELDS

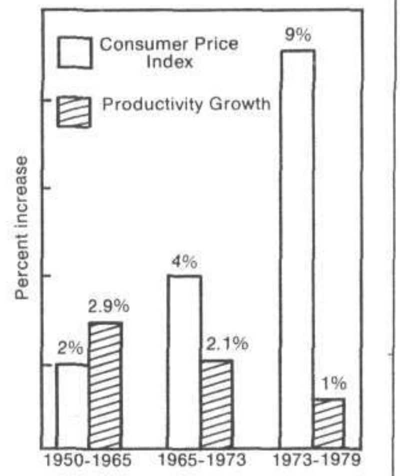


Figure 3
INFLATION VERSUS PRODUCTIVITY GROWTH

Productivity growth in manufacturing and the training of PhD's in scientific fields reached postwar highs at the height of the NASA program. When NASA funding was reduced, the effects were promptly felt in lower productivity growth, which contributed to the runaway inflation of the 1970s. Data from Bureau of Labor Statistics (Figures 1 and 3) and National Science Foundation (Figure 2).

ent problem. Nuclear fission technologies must soon give way to nuclear fusion technologies—the huge quantities of high energy density, low-entropy energy that fusion generates will power Earth in the 21st century. However, economic studies show that we will face a critical shortage in the beginning stages of the transition to fusion: We will not have enough people. Estimates are that the division of labor, supporting populaton, and engineering base required for a fusion-based economy will demand 10 billion people. We need more people; that is the real population crisis.[2]

Thus, the project for the colonization of space is intimately bound up with Earth's present need for Third World development, through nuclear energy and the transition to nuclear fusion technologies in the 1990s and into the 21st century. Space is not a bastion for star wars fantasies and science fiction; it is an essential link in the process of progress and technological development. This development can occur only along lines very similar to those responsible for man's successful development up to this point: big, centralized, energy-intensive and capital-intensive projects, exactly like the space program itself.

Over the last 20 years, the NASA program has been remarkably successful in creating the possibility for the codevelopment of Earth and space. In fact, its very success has resulted in attacks on NASA by opponents of technological development.

This opposition comes from both sides of the antitechnology spectrum. On the one side, the L-5 Society, Gerard O'Neill, and their cothinkers propose space exploration and space colonies as the ultimate in decentralized, nonnuclear, solar-powered paradises. As O'Neill says in his latest book, *2081*, our future lies in "happy communes" in space that use modern technology only to transport the commune inhabitants from Earth to their home in space.

On the other side, the Tavistock Institute, the Club of Rome, and others concerned with the control of technology have defined NASA as the most dangerous promoters of unbridled technological innovation and what they see as the social upheaval that such technological change inherently involves.

What the antidevelopment factions see, in many ways more clearly than NASA itself, is the revolution brought about on Earth by space exploration. Inherent in an aggressive space program is the economic momentum of technological development. NASA has tended to call these economic implications "spinoffs." But any colonization program that resulted only in the accidental, peripheral benefits of spinoffs could not succeed.

Spinoffs are the outcome of a failed exploration attempt, the backwash of a tide of colonization that receded without success. NASA's impact on the U.S. economy cannot be accounted for by a mere listing of its spinoffs; NASA has laid the basis for a revolution in the U.S. economy.

The empirical evidence of the beneficial effects of the space program on the U.S. economy are straightforward.

Productivity. As Figure 1 shows, productivity growth in the U.S. economy reached a postwar high at the same time as the NASA program. This correlation reflects the far-reaching impact of NASA's investment in high-technology industry and the innovation in materials, computers, and engineering techniques.

Capital investment. Capital investment also depends on new technologies. After the Apollo program peaked in 1967, the U.S. economy as a whole began to show symptoms of a fundamental sickness, the result, in significant part, of a fall in capital investment. Without the spur to technological innovation provided by an aggressive space program, capital investment began to fall.

Manpower training. Figure 2, showing the number of graduating engineers and scientists in the United States, is an even more disturbing indication of the destruction of the economy that accompanied the loss of the Apollo program. Without Apollo, the tremendous boost to manpower development that NASA provided was gone, and the number of science and engineering graduates plummeted.

Inflation. NASA spending even kept inflation down! As a 1976 study by Chase Econometrics pointed out, NASA spending is much less inflationary than other, lower technology government spending. Figure 3 compares the rate of inflation since 1950 with productivity growth in the same period—an amazing record.

The obvious point is that NASA's space program is capable of not merely paying its way many times over—a rather trivial point to any but the most unimaginative—but the NASA program is capable of vectoring the development of the Earth-bound economy in such a way that further exploration and colonization are possible.

If the 1960s were a proof-of-principle experiment in the ability of space exploration to power the U.S. economy, the 1970s were a demonstration of necessity for a vital space program. Without an aggressive base for technological innovation like that from the space program, the U.S. economy has stagnated, and it will continue to do so unless there is a recommitment to space research.

The cause of NASA's spectacular impact on the U.S. economy is new technology. It is the introduction of new technologies that raises productivity, increases capital investment, and requires the training of engineers. These new technologies spread throughout the entire economy, but have been especially spectacular in four areas—new materials, miniature electronics, communications, and basic science research.

Materials science. The harsh and demanding environments encountered by a spacecraft demanded the solution to an entirely new complex of problems in materials science. Materials had to be capable of withstanding high temperatures and mechanical stress, yet they had to be lightweight as well. NASA's solution went in two directions, new plastics and new ceramics. Fluorocarbon plastics, chemically impervious and strong, were one solution, and high-density ceramics were another. Both have revolutionized the materials used for consumer goods (artificial organ parts, Centura dishware) and capital goods (ceramic turbines, improved electrical insulation).

The frontier of practical science opened up by these developments continues to astound scientists and engineers—composite materials, new alloys, lightweight ceramics, are but a few. Space exploration has, for the first time, seriously challenged the monopoly that metals had as the stuff of technological advancement.

Miniaturized Electronics. Without doubt the best known contribution of the space program to everyday life and economic activity is the development of microelectronics. The gaudiest marvels of the consumer trade, calculators, electronic games, and the like, owe their existence to the space program. NASA program engineers had to master for the first time, cheap, highly complex circuits used in miniaturized logic circuits. The breakthroughs in this area quickly became the norm for military and civilian electronics alike.

The impact of these miniature electronic circuits, however, is much more qualitative than quantitative. Like many new technologies, the impact was not merely to introduce new products or improve the efficiency with which existing products were produced. Rather, these electronic innovations have revolutionized almost every

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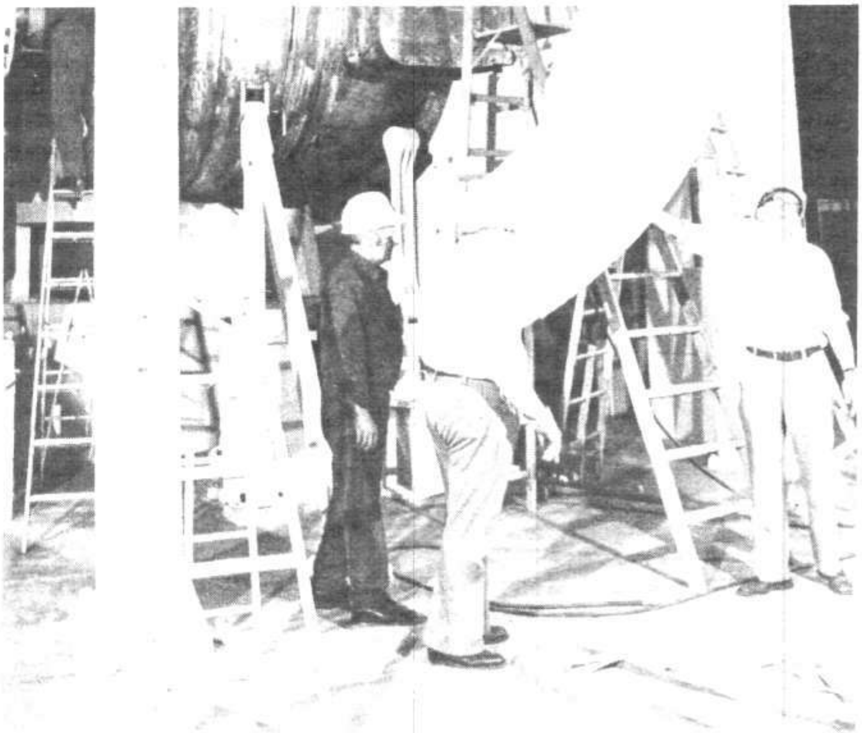
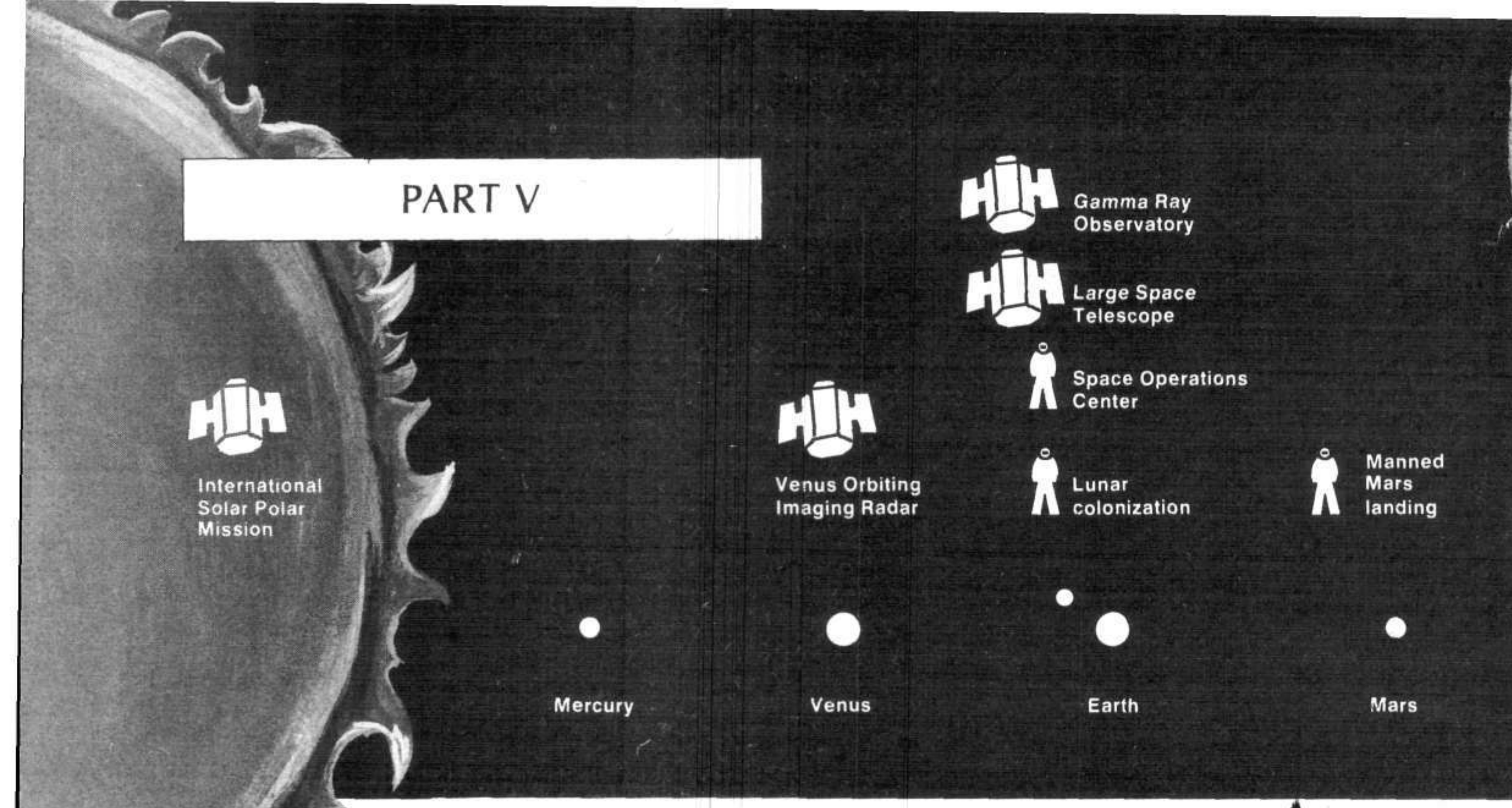


PPPL

To successfully explore and colonize the solar system requires the development of the most advanced technology on Earth. Here technicians at Princeton Plasma Physics Laboratory in New Jersey assemble a mock-up of the largest U.S. fusion reactor, the TFTR, scheduled for operation in mid-1982.

PART V



THE U.S. SPACE PROGRAM IN THE 1980s
Shown here are the missions that could be undertaken during the next 10 years, manned and unmanned. The Space Operations Center, a permanently manned orbiting space station, will be the stepping-stone for all space colonization plans for the future. Then it will be time for the next step in exploring the inner planets: the manned exploration of Mars and the settling of the Moon.

The Next Decade in Space

A program for space exploration and colonization must include all four stages of space activity at any given time. As man ends the first stage of unmanned exploration of the nearby celestial bodies like the Moon, for example, his scientific instruments must probe farther into the reaches of the solar system—and then the rest of the universe—to prepare the way for men to follow.

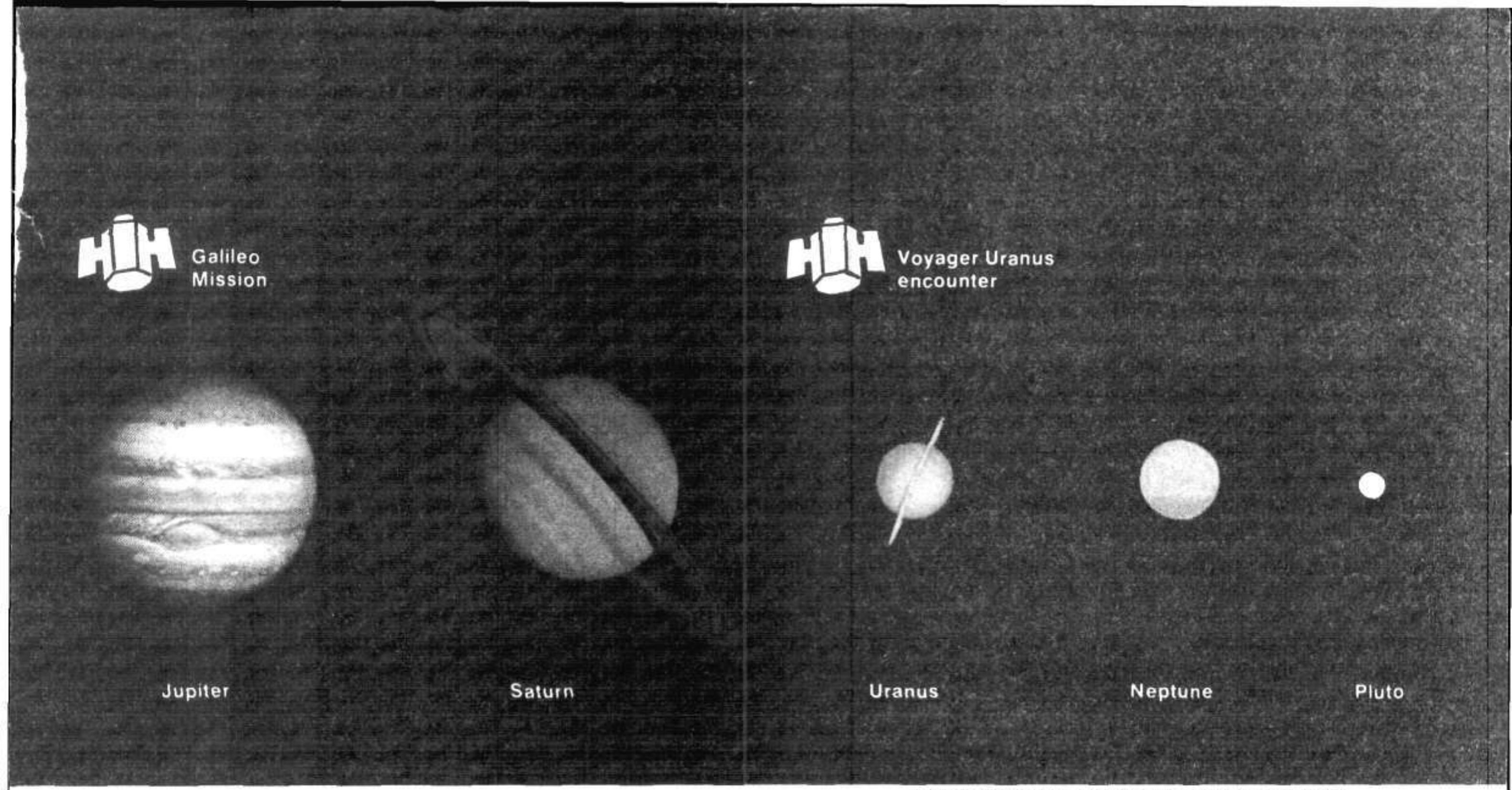
The next step in the drive to spread "human civilization in the universe" will be a permanently manned U.S. space station in Earth orbit, a *Space Operations Center* (SOC). The SOC, which is under preliminary design by NASA, will make space a livable environment for Americans, much as the Salyut space stations have done for the Soviet space program.

From this permanent base in Earth orbit, serviced by a fleet of Space Shuttles, other currently impossible tasks in space become possible, such as travel to farther points and the construction of large space structures. The SOC must be an operational goal of the 1980s.

Once the SOC and related stages are completed, then we can plan to send people to colonize the places we have sufficiently explored, such as the Moon. And as we continue to send probes and scientific instruments to the farther reaches of the universe, we can begin to set our sights on manned landings and then a base of operations on Mars and other planets.

NASA is ready now to initiate new unmanned exploratory probes into regions as yet only observed from Earth or near-Earth. In the mid-1980s, the world will have the unique opportunity to send unmanned satellites near Halley's comet to make fundamental observations about the nature of these periodic bodies. Although the Europeans and the Soviets have such missions planned, the fate of the U.S. *Halley's comet probe* is uncertain. This program should immediately be funded and implemented.

NASA is also ready to send high-powered observatory instruments, such as the *Large Space Telescope* and the *Gamma Ray Observatory*, into space to improve Earth-based universe observations more than 200-fold. President Reagan has proposed reducing the funding for the Gamma Ray Observatory from $52 million to $8 million, thereby



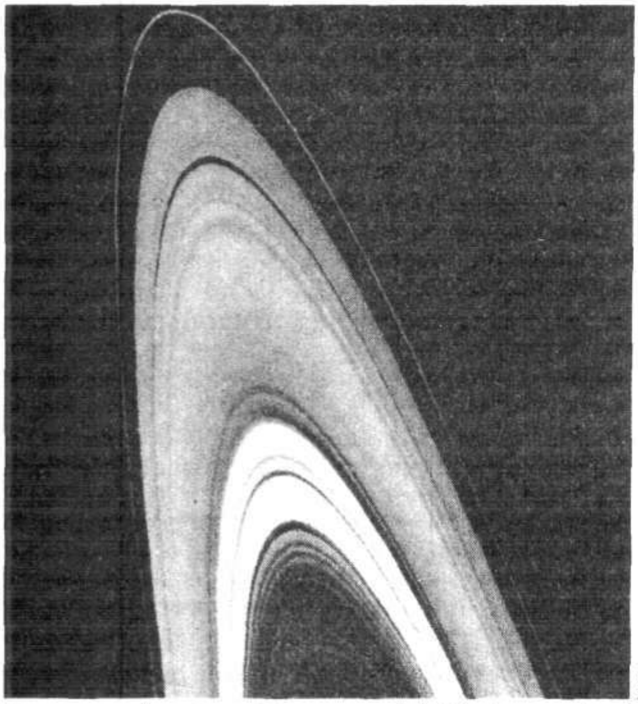
As the next step in the exploration of the outer planets, the Galileo Mission to Jupiter could tell us more about this planet's mysterious atmosphere. Similarly, the surface features of Venus could be mapped more precisely through the Venus Orbiting Imaging Radar probe. The Gamma Ray Observatory and the Large Space Telescope, both deployed from the Space Shuttle, will vastly expand our view of the universe—10 billion light years farther than current astronomical equipment allows us to see. The proposed International Solar Polar Mission would provide the first three-dimensional picture of the Sun.

delaying its deployment by the Space Shuttle from 1986 to 1988. Full funding would provide us with crucial information about the far edges of the universe to later allow unmanned probes and eventually man to venture beyond the solar system.

The International Solar Polar Mission, planned jointly by NASA and the European Space Agency, is a unique opportunity to observe our own star at close range with two spacecraft. This would give us our first three-dimensional look at the Sun as well as data about many other stars in the galaxy. However, President Reagan's NASA budget request has eliminated the U.S. craft for the mission, which destroys the Solar Polar project. This unmanned program is crucial for basic scientific progress, and should go ahead at the $58 million originally requested.

Taking a Better Look

At the same time that stage-one exploration of new bodies is expanding, we must return to places we have already visited preliminarily to take finer measurements



The spectacular views of Saturn provided by Voyager have overturned the accepted theories of physics and celestial mechanics. Here the underside of Saturn's rings taken by Voyager 1 on Nov. 12, 1980, 740,000 kilometers from Saturn.

and samples that will help determine the next step for manned exploration. The *Galileo Mission,* for example, proposes to return to Jupiter in order to refine and expand the knowledge gained from the unmanned Voyager missions.

Galileo would drop an unmanned probe down to the surface of the planet that would take measurements of the atmosphere and near-surface of Jupiter for about an hour before it burned up in Jupiter's hot gases. The full $158 million funding for Galileo is crucial to extend our knowledge about outer planets.

At the same time, we must return to Venus to bring more sophisticated scientific equipment that will allow a mapping of the clouded planet. The *Venus Orbiting Imaging Radar* mission has been designed to orbit the planet and make such a radar map. However, the Reagan administration is proposing to delay the mission two years to 1988 and cut the fiscal year 1982 funding from $40 million to $10 million. Going ahead with the speed the technology will allow will answer our questions about Venus in this decade.

There are also many fundamental questions about Earth that are important to answer. The *Upper Atmosphere Research Satellites Experiment* to measure the chemical, magnetic, and other features of the atmospheric blanket that protects the Earth has been cut $10 million, which will unnecessarily delay the program.

During the past decade, the only manned space program has been the *Space Transportation System,* or Shuttle. To make this vital system fully operational, a commitment must be made to spend the $500 million for the fifth Shuttle Orbiter and to keep the original schedule for the scientific flights of the European-built Spacelab. Without such a commitment, we will not succeed in our goal of a manned program that leads to permanent colonies in space.

A World Population Big Enough

Continued from page 19

aspect of the economy—a revolution without which the automation and advanced machinery required for Earth to support space colonization could not have been achieved.

Communications. The lubricant of modern industrial society is its communications infrastructure. On one level it appears to be an overhead expense (it certainly does not produce tangible goods), but the speed and reliability of communications have a direct impact on the productivity of industrial production. Some of the most dramatic effects of the space program have been in the area of cheapening long-distance communications, vastly expanding the scale of possible communications, and improving the reliability of existing communications.

The very fact of speeding up communications has decreased both the time and expense of all aspects of industrial production.

Basic scientific research. The most exciting contribution of space to the Earth's economy is space as a new laboratory. Our solar system offers three opportunities for basic scientific research otherwise unavailable: a gravity-free environment, an unobstructed view of the universe, and access to large bodies of matter in extreme conditions.

In a gravity-free laboratory, exotic alloys are being developed and tested. These alloys cannot be made on the Earth because gravity will separate the immiscible components before the metal cools. In space, very pure, uniform samples can be prepared. In the same way, "perfect" ball-bearings can be manufactured. The Soviet Union has been conducting such experiments during the course of its Soyuz manned missions, and the United States is just beginning with the Shuttle's Spacelab.

The establishment of observatories in space has opened up the entire electromagnetic spectrum to our observation. No longer restricted to the small windows of radiation unabsorbed by the atmosphere, we now have access to kinds of astronomy never dreamed of before. X-ray observations have pinpointed bizarre stellar objects like quasars, seemingly billions of light years distant and emitting the energy of thousands of galaxies; and pulsars, intense sources of radiation that turn on and off many times a minute. Radio astronomy has begun mapping the surprisingly complex organic chemistry of galactic clouds. Even optical observations have increased the distance we can see by a factor of 50.

The practical impact of this research is nicely shown by new data available from the Voyager views of Jupiter and Saturn. These planets are large masses of un-ionized hydrogen at whose center the mixture is under millions or hundreds of millions of atmospheres pressure. At these pressures, hydrogen, the lightest element, is thought to be a metallic solid! Now, the most difficult problem to solve in achieving nuclear fusion using lasers (inertial confinement fusion) is that of predicting the behavior of the hydrogen fuel as it is compressed to densities comparable to those at the core of Jupiter. Solve this problem and the virtually unlimited energy source of fusion power will be near at hand. We will have fusion energy not only to drive economic development here on Earth, but also to power the high-thrust spaceships that will eventually carry man across the solar system and beyond.

Terrestrial high pressure experiments can provide only a small glimpse of the behavior of hydrogen at the conditions necessary for achieving fusion. The Voyager satellites provided largely complementary data on hydrogen at high pressures. Between the two, an equation of state for solid hydrogen is being derived. This research shows in a microcosm the long-term impact of the basic research made possible in space.

The Future

As Senator Schmitt asked, and answered, in the foreword to this pamphlet, "Where are we going with our civilization?" We have no alternative but to move civilization into space—and to organize the American public to see that the job gets done.

Notes

1. For the case of Mexico, see *Fusion*, July 1981; for the case of India, see *Fusion*, May 1980.
2. See *Fusion*, Sept. 1981, "The World Needs 10 Billion People."

Restoring NASA's Role

Since 1958, NASA has been the agency that plans American progress in science and technology; it is the nation's primary scientific capability. Every dollar cut from NASA's funding levels reduces the United States role in the world more surely than any defense cut.

To restore NASA to its level of activity and manpower of 1965, the peak of the Apollo program, would mean a budget of $14 billion per year. This budget level will determine not only the pace of the space program, but also the health of our economy: its growth in productivity, its rate of reinvestment, and its levels of skilled manpower development.

The primary goal of the space program during the 1980s must be the establishment of a Space Operations Center (SOC)—a permanently manned, orbiting space station. The colonization of the solar system cannot proceed without this SOC. All the exciting scientific missions, exploratory satellites, and manned expeditons will be meaningless, dead-end endeavors without the establishment of a beachhead in space.

The creation of a manned space station by the late 1980s will pave the way for the establishment of the first permanent laboratories on the Moon, to be followed by settlements there. It will be the way-station for all manned exploration to the farther reaches of the solar system.

Here's What NASA Needs

- Funding to carry out the completion of a full *Space Transportation System*, including the Space Operations Center and the other necessary steps of space colonization and industrialization.
- Funding for the *Halley's Comet* probe, a unique mission possible in the mid-1980s.
- Funding for the *Large Space Telescope* and the *Gamma Ray Observatory* into space, which will improve Earth-based universe observations more than 200-fold.
- Funding for the *International Solar Polar Mission,* planned jointly with the European Space Agency to give us our first three-dimensional look at the Sun.
- Funding for the *Galileo Mission,* which would return to Jupiter to supplement the knowledge gained from the Voyager missions.
- Funding for the *Venus Orbiting Imaging Radar* mission, which will allow us to map the clouded planet.
- Funding for the *Upper Atmosphere Research Satellites Experiment,* which will measure the chemical, magnetic, and other features of the atmospheric blanket that protects the Earth.