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OA/ID Number: 04014
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Folder Title:
National Space Council [1]

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Withdrawal/Redaction Sheet

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Doc. No. / Type	Subject/Title	Date	Restriction	Classification
01 Memo	From Mark J. Albrecht to Distribution List Re: New Space Launch Vehicle [Name redacted] (1 pp.)	4/19/91	(b)(3)	
02 Memo	From Mark J. Albrecht to Distribution List Re: U.S. Commercial Space Policy Guidelines [Name redacted] (1 pp.)	1/8/91	(b)(3)	
03a. Note	From Mark Albrecht to Ed Rogers Re: Augustine Panel (1 pp.)	n.d.	P-5	
03b. Memo	From Mark Albrecht to VPOTUS Re: Status of the Space Advisory Committee (6 pp.)	11/8/90	P-5	
04 Paper	Draft Background for Congressional "Space Summit" 4/16/90 (7 pp.)	n.d.	P-5	
05a. Memo	From Mark J. Albrecht to the Policy and Implementation Review Committee Re: Commercial Space Launch Policy and Strategy Review (1 pp.)	3/22/90	P-5	
05b. Paper	Extract from Draft of Commercial Space Launch Policy and Strategy (2 pp.)	n.d.	P-5	

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Collection:

Record Group: Bush Presidential Records
Office: Chief of Staff to the President, Office of the
Series: Rogers, Edward
Subseries:
WHORM Cat.:
File Location: National Space Council [1]

Pinksheet Number: KO0466
OA/ID Number: 04014-014
Date Closed: 11/19/2004
FOIA/Sys Case #: 1999-0093-F
Re-review Case #: 2005-0367-S
P-2/P-5 Review Case #:

Withdrawal/Redaction Sheet

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Doc. No. / Type	Subject/Title	Date	Restriction	Classification
05c. List	Policy Implementation Review Committee [Name redacted] (1 pp.)	3/22/90	(b)(3)	
06a. Memo	From Vice President Quayle to President Bush Re: Space Council Recommendations [OPEN ON PRA APPEAL; DOCUMENT FOLLOWS] (2 pp.)	2/13/90	P-5	
06b. Paper	Attachment: Expanded Discussion of Proposed Policy Space Exploration Initiative (3 pp.)	n.d.	P-5	
07. Memo	From Mark j. Albrecht to Governor Sununu Re: Dinner at the Vice President's Residence, February 7, 1990 (3 pp.)	2/20/90	P-5	

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Date Closed:	11/19/2004	OA/ID Number:	04014-014
FOIA/SYS Case #:	1999-0093-F	Appeal Case #:	
Re-review Case #:	2005-0367-S	Appeal Disposition:	
P-2/P-5 Review Case #:		Disposition Date:	
AR Case #:		MR Case #:	
AR Disposition:		MR Disposition:	
AR Disposition Date:		MR Disposition Date:	

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Presidential Records Act - [44 U.S.C. 2204(a)]

- P-1 National Security Classified Information [(a)(1) of the PRA]
- P-2 Relating to the appointment to Federal office [(a)(2) of the PRA]
- P-3 Release would violate a Federal statute [(a)(3) of the PRA]
- P-4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
- P-5 Release would disclose confidential advice between the President and his advisors, or between such advisors [(a)(5) of the PRA]
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- (b)(6) Release would constitute a clearly unwarranted invasion of personal privacy [(b)(6) of the FOIA]
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- (b)(9) Release would disclose geological or geophysical information

NATIONAL SPACE COUNCIL
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20500

April 19, 1991

MEMORANDUM FOR MR. J. STAPLETON ROY
Executive Secretary
Department of State

MR. WILLIAM SITTMANN
Executive Secretary
National Security Council

MR. R. BLAIR DOWNING
Executive Secretary
Department of Treasury

MR. JAMES MURR
Associate Director
Office of Management
and Budget

COL JOHN A. DUBIA
Executive Secretary
Department of Defense

DR. ALLAN BROMLEY
Director
Office of Science and
Technology Policy

MR. MARK LIEBERMAN
Assoc. Deputy Secretary
Department of Commerce

CAPT Norbert Ryan
Executive Assistant
to the Vice Chairman
Joint Chiefs of Staff

MS. RUTH KNOUSE
Director, Executive
Secretariat
Department of
Transportation

MS. JESSIE HARRIS
Executive Officer
National Aeronautics and
Space Administration

GOV. JOHN H. SUNUNU
Chief of Staff
to the President

(b)(3)

DR. FENTON CAREY
Special Assistant
to the Secretary
Department of Energy

SUBJECT: New Space Launch Vehicle

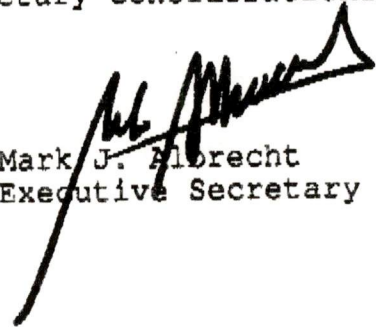
The Vice President asked that Space Council members be informed of the following actions taken with regard to the development of a new space launch system.

The Department of Defense and the National Aeronautics and Space Administration will undertake the joint development of a new space launch system to meet civil and national security needs. The goal of this launch program is to greatly improve national

launch capability with reductions in operating costs and improvements in launch system reliability, responsiveness and mission performance. The agencies will actively consider commercial space launch needs and factor them into decisions on the program.

The new launch system, including manufacturing processes and production and launch facilities, will be designed to support a range of medium to heavy lift performance requirements and to facilitate evolutionary change as requirements evolve. The design may take advantage of existing components from both the Space Shuttle and existing expendable rockets in order to expedite initial capability and reduce development costs. While initially unmanned, the new launch system will be designed to be "man-ratable" in the future.

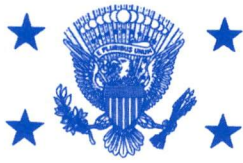
The new launch system will be jointly funded and developed with each agency providing \$175 million in FY 1992, \$275 million in FY 1993, and appropriate amounts in subsequent years. The development program will be structured in the near term toward the goal of a first flight in 1999. However, the program should allow for several schedule options for the first flight and should identify key intermediate milestones. Final decisions on the program schedule, including the date of the first flight, will be made during fiscal year 1993, based on updated requirements and technical and budgetary considerations at that time.


Mark J. Albrecht
Executive Secretary

NATIONAL SPACE COUNCIL



1990 Report to the President



THE VICE PRESIDENT WASHINGTON

JANUARY 4, 1991

Last year President Bush charged the National Space Council with nothing less than helping chart a course to a future marked by global prosperity, a robust and protected environment, and unprecedented scientific achievement.

He said that, "America's space program is what civilization needs." America, with its tremendous industrial and technological resources, is uniquely qualified for leadership in space. But more important, our success will be guaranteed by the American spirit — the same spirit that tamed the North American Continent and built enduring democracy.

The National Space Council's task is to bring coherence, continuity, and commitment to our efforts in space. The President asked us to lead America's national security, civil and commercial space resources in a cooperative effort to chart a prudent, but progressive path toward the future. He committed the Council to integrate the tremendous scientific, private-sector, and technological resources of our nation in a noble cause — harnessing the potential of space to benefit our great nation and serve all mankind.

As Chairman, I am pleased to report that the National Space Council has made important progress in the past year. We have translated vision into goals and established a conceptual foundation to mesh America's diverse government programs with private-sector space efforts into a coordinated thrust forward.

Our initial effort was to define the key elements of our national space strategy. These five areas are:

Developing space launch capability and supporting infrastructure as a national resource

A robust, reliable, available, and affordable launch capability is critical to success in space. We are engaged in reviewing current and needed capabilities to meet the nation's many objectives. This problem must be approached from a nation-wide perspective. It is already clear that our future fleet will consist of an appropriate mix of federal and commercial systems using both manned and unmanned vehicles. Diversity is important, so we are encouraging various private and state government enterprises as well as international efforts. Supporting the research and development of revolutionary new space transportation concepts such as the National Aerospace Plane and evolutionary ones such as the Advanced Launch System are important to a successful future in space.

Opening the frontiers of space

The President approved a major Space Exploration Initiative that builds on the successes and expertise built up in the Apollo, Skylab, Space Shuttle and Space Station Freedom programs by setting the goals of returning to the Moon to stay and exploring Mars. A comprehensive long-term program to study the universe is already in place, starting with the Hubble telescope, which, despite its difficulties, will soon give us a much deeper understanding of the universe. (Moreover, corrections will be made that will allow the telescope to reach its full design potential.) It includes three more Great Observatories in space. Our planetary exploration program continues to build on the spectacular successes of Voyager and Viking. Galileo is on its way to Jupiter, and Magellan is orbiting Venus. Spacecraft to explore a comet, Saturn and its moons are being built. We are committed to the use of government resources, in cooperation with the private sector, to encourage dramatic innovation in exploring space and to infuse every segment of our society with excitement over the prospects in space. Also important is the groundwork being laid by the Council for international cooperation, a natural extension of the cooperation already in place for Space Station Freedom and the majority of NASA programs over the last 30 years.

Using space to solve problems on Earth

Americans are highly dependent today on space systems for such commonplace functions as placing long-distance telephone calls and watching real time news events from across the globe on the television. But space also provides communication, navigation, and surveillance vital to our national security. Further, the world's ecological, climatic and energy crises—literally life threatening—cannot be solved without the success of efforts such as NASA's Mission to Planet Earth initiatives. The Council's review of Landsat data sales, and its subsequent decision to maintain federal funding, indicate the direction needed to ensure success in this important area.

Later, based on the understanding space will give us of the Earth, space can provide solutions to many of the problems we face. A prime example is the potential, in the future, for the provision of clean, limitless energy to Earth from space, using materials mined on the Moon.

Generating economic well-being and national competitiveness

America's industrial and technological leadership underpin our economic success and international competitiveness. The opportunities for everything from developing Earth-bound industrial capabilities based on space technology to creating new industries in space are likely to revolutionize America's economy. The Council is focusing on our commercial space policy to implement new ideas for cooperative efforts between various industries, the government, and civil institutions. Our goal is to ensure the consistent, predictable implementation of that policy. Among the promising avenues immediately at hand are such things as global cellular telephone systems; international high-definition television; unprecedented accuracy in aircraft and marine navigation; affordable position-location systems for small aircraft, boats, trucks, and even individuals; and direct broadcasting of both radio and television to millions of homes throughout the world. Furthermore, scientific ventures in space not only expand our knowledge and understanding of the universe, they lead also to the development of technologies and processes that impact directly on commercial progress.

Ensuring freedom to use space

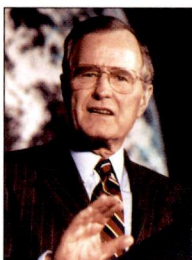
Space, like the oceans, is a medium of travel, an as-yet unexploited repository of natural resources, and a strategically useful domain. To protect the freedom of space we must be able to do three things: First, we must be able to see and monitor all that occurs in space. Second, we must be able to alert and warn owners and operators of space systems that threats exist. Third, we must develop the capability to intervene to protect our and other nations' space assets.

In conclusion, we have begun developing strategies for implementing a sound program of achievement in each of these five areas. Our efforts in each case are guided by our belief that a broadly-based, cooperative effort involving the national security, civil, and commercial space sectors is the only sure path to success. The National Space Council is seeking to infuse our space efforts with the same breadth that has always characterized our nation's greatest successes—whether in science, technology, or commerce.

The time has come to look beyond brief space encounters and to commit to a future where Americans and citizens of all nations will live and work in space. To ensure our institutions, strategies, and programs are on track we organized an outside advisory committee on the Future of the U.S. Space Program that gave us a no-holds-barred examination of our goals and objectives in space and how we plan to achieve them. The report clearly points out the need for fundamental changes in our civil space program. We will make changes. I am confident that the recommendations of the committee will form a solid foundation for America's space program for many years to come.

In the attached progress report, we have detailed our review of space policy and related issues in each of the areas described above and have identified the paths for pursuit of these goals. Necessarily, many of our actions are preliminary, but they demonstrate the Council's commitment to a rational, coherent program in space and recognize that we are now at the threshold of charting our future. We are committed to bringing the tremendous strengths of America's public and private sectors to bear on this frontier, rather than constraining or regulating them. We are committed to cooperation at every level and to making maximum use of every opportunity. This report tells how we have begun to implement these commitments.





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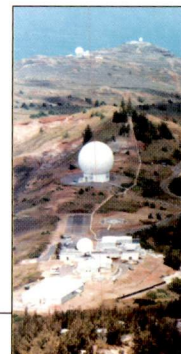
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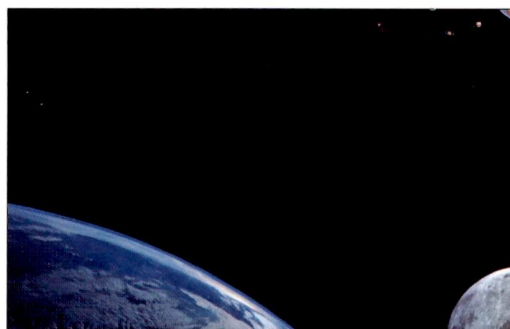
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The National Space Council

The National Space Council is responsible for the coordination of U.S. space policies and strategies and for monitoring their implementation. It was created by an act of Congress in 1988 and was established by President Bush's Executive Order No. 12675 on April 20, 1989. In signing the Order, the President said that space is of vital importance to the nation's future and to the quality of life on Earth, and he charged the Council to keep America first in space.

The Council is chaired by Vice President Dan Quayle, who serves as the President's principal advisor on national space policy and strategy. Other members of the Council include:

- The Secretary of State
James A. Baker, III
- The Secretary of the Treasury
Nicholas F. Brady
- The Secretary of Defense
Dick Cheney
- The Secretary of Commerce
Robert A. Mosbacher
- The Secretary of Transportation
Samuel K. Skinner
- The Secretary of Energy
James D. Watkins
- The Director of the Office of Management and Budget
Richard G. Darman
- The Chief of Staff to the President
John H. Sununu
- The Assistant to the President for National Security Affairs
Brent Scowcroft
- The Assistant to the President for Science and Technology
D. Allan Bromley
- The Director of Central Intelligence
William H. Webster
- The Administrator of the National Aeronautics and Space Administration
Richard H. Truly

The Vice President invites the participation of the Chairman of the Joint Chiefs of Staff, the heads of other departments and agencies, and other senior officials in the Executive Office of the President when the topics under consideration by the Council so warrant.

The National Space Council is supported by an Executive Secretary appointed by the President. The first Executive Secretary of the Council, Mark Albrecht, leads an eleven-member policy staff. The Council is further supported by a sub-cabinet-level inter-agency Policy Implementation and Review Committee (PIRC) composed of senior representatives of each member of the Space Council and chaired by the Space Council's Executive Secretary. Interagency working groups, chaired by Space Council staff, prepare policy studies, develop strategy alternatives, and provide advice and recommendations to the PIRC. The Administration's budget request for FY 1991 will support a dedicated Council Staff of fourteen and a Space Policy Advisory Board of private citizens, authorized by the Executive Order which established the Council.





Secretary of State



Vice President



Secretary of the Treasury



Secretary of Defense



Secretary of Commerce



Secretary of Transportation



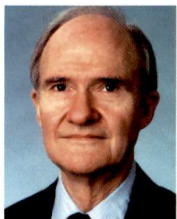
Secretary of Energy



Director of the Office of Management and Budget



Chief of Staff to the President



Assistant to the President for National Security Affairs



Assistant to the President for Science and Technology



Director of Central Intelligence



Administrator of NASA



Executive Secretary
Mark Albrecht

The National Space Council carries out activities to integrate and coordinate civil, commercial, and national security space activities and has taken major steps toward their implementation.

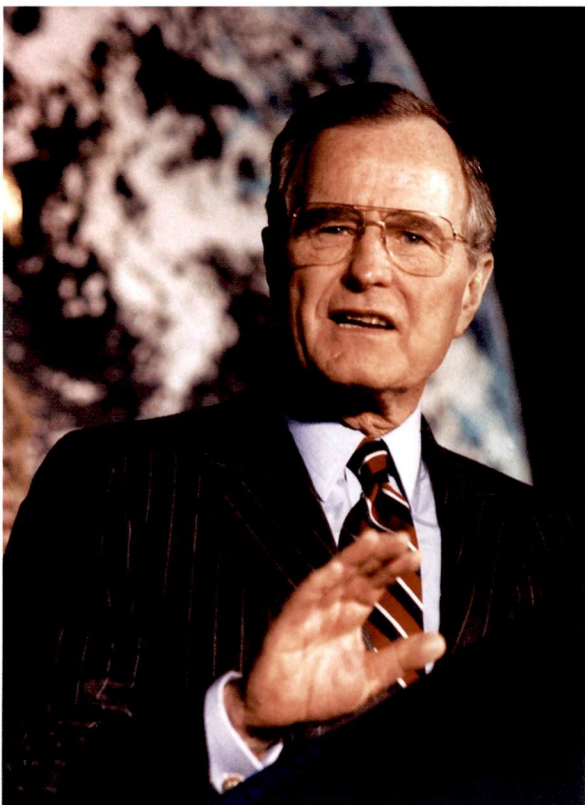
The Council's planning process consists of four phases:

- Define broad goals and objectives for the U.S. space program;
- Determine strategies to implement those goals and objectives;
- Monitor the implementation of these strategies; and
- Resolve specific issues that arise during the implementation process.

"I believe that before Apollo celebrates the 50th anniversary of its landing on the Moon, the American flag should be placed on Mars."

Since signing the Executive Order that established the National Space Council, President Bush has made clear his resolve that this nation will lead the world in space. His landmark speech on July 20, 1989, the 20th anniversary of the Apollo Moon landing, established America's goals in space exploration: "... a long-range continuing commitment... first for the coming decade — Space Station Freedom — our critical next step in all our space endeavors. And next, for the new century — back to the Moon. Back to the future. And this time, back to stay. And then — a journey into tomorrow — a manned mission to Mars..."

The President reaffirmed his resolve in his speech at the University of Tennessee on February 2, 1990: "...first in space will mean first on Earth. And America intends to stay No. 1 ...Our goal: To place Americans on Mars — and do it within the working lifetimes of the scientists and engineers who will be recruited for the effort today..." A subsequent speech at Texas A&I University on May 11, 1990 put a firm date — 2019 — on his goal: "I believe that before Apollo celebrates the 50th anniversary of its landing on the Moon, the American flag should be placed on Mars."



The Vice President, too, has demonstrated publicly his strong support for the President's space objectives. He enunciated U.S. National Space Strategy in a major address to the American Astronomical Society on January 10, 1990: "First, we intend to develop our space launch capability and its related infrastructure as a national resource ...Our second goal is to open the frontiers of space. This includes manned and unmanned programs. ...[Third,] the National Space Council is committed to intensifying our use of space to deal with problems on Earth. ...[Fourth,] we believe the exploration of space will enhance our economic well-being and our overall national competitiveness, ... and the final element of our strategy, of course, is ensuring that our space program contributes to our nation's security..."

Having defined the Space Council's planning process for implementing the President's goals in space, the Vice President laid before the American people his rationale for a strong and comprehensive civil space program. At the U.S. Space Foundation's Sixth National Space Symposium in Colorado Springs on April 10, 1990, he said "...in the next century space may be key to allowing us to satisfy our energy needs from space without damaging the environment; providing us with increased access to rare and essential metals and minerals; and allowing us to develop new information services which could further the revolution in commu-

nications which has already begun. And of course, in the next century, research in space could lead to new medicines or medical treatments of incalculable benefit to mankind..."

Three weeks later, at the Annual Meeting of the American Institute of Aeronautics and Astronautics in Washington, D.C. on May 1, 1990, the Vice President emphasized, "Our future competitiveness will depend on advancing technology...on educating our young people for excellence in math and science. The space program is a sound investment in ensuring that these key aspects of American competitiveness are there when we need them."

"Our future competitiveness will depend on advancing technology ...on educating our young people for excellence in math and science. The space program is a sound investment in ensuring that these key aspects of American competitiveness are there when we need them."



National Space Council Planning Process

To guide national space activities and ensure an integrated national space program, the Space Council has designed a planning process consisting of four phases.

In its first year, the National Space Council made a strong start toward implementing this planning process and establishing essential strategies.

1

Establish broad goals and objectives for the U.S. space program.

The Council revised the 1988 National Space Policy and reissued it as Directive #1. This new policy was approved by President Bush on November 2, 1989. It provides the basic goals and overall policy guidance for the U.S. space program.

The new directive clarifies, strengthens, and streamlines policy in selected areas such as civil and commercial remote sensing, space transportation, space debris, federal subsidies of commercial space activities, and Space Station Freedom.

Most importantly, however, it revalidates the ongoing direction of U.S. space efforts and provides a broad policy framework to guide future U.S. space activities. It reaffirms the nation's commitment to the exploration and use of space in support of our national well-being and it recognizes that leadership requires American pre-eminence in areas of space activity critical to national security and to achieving our scientific, technical, economic, and foreign policy goals.

2

Establish strategies to implement these goals and objectives through an integrated nation-wide set of activities.

The Council formulated a Space Exploration Initiative. The President signed the implementing Policy Directive on February 13, 1990. He also signed a second policy directive to explore international cooperation in this initiative.

The Council is also currently formulating a space launch vehicle policy and a separate, but related policy on commercial uses of space.

KEY ELEMENTS OF NATIONAL SPACE POLICY

Transport



3

Monitor the implementation of these strategies.

To monitor implementation of Presidential policies, the National Space Council establishes working groups consisting of representatives of Space Council member agencies as well as other affected departments and agencies. These working groups review progress toward accomplishing Space Council goals and implementing Presidential space decisions and policies. They then formulate position papers and issue papers to be forwarded to the full Space Council for information and action.

One example of Space Council implementation monitoring is the activity following the President's decision to explore possible international cooperation in our exploration initiative. In response, a working group was formed consisting of members from the involved departments and agencies and chaired by a Senior Space Council Staff Officer. This group meets frequently and has prepared agreed upon guidelines for discussions with potential international partners. As this dialogue develops in 1991, the working group will continue to monitor the discussions and forward status and decision memos to the Space Council.

4

Resolve specific program or policy issues arising from ambiguities or disagreements in implementing the strategies.

Several program issues that arose as a result of changing circumstances or past policy ambiguities were resolved.

The Landsat remote sensing program—the Council recommended reinstating government funding because of the government's continuing need for Landsat data and the inability of the private sector to obtain sufficient business for commercial viability.

National Aerospace Plane policy—here the Council recommended focusing the program objectives on proving the requisite technologies, including a flight of a test aircraft; and continuing management of the program as a national enterprise.

The Council approved a U.S. Commercial Space Launch Policy providing important guidance for encouraging the competitiveness of private sector space activities. To achieve this goal the Council has specified a coordinated set of actions for the next ten years.

SPACE STRATEGY

ation

Solutions

Opportunity

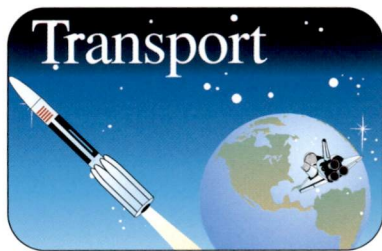
Freedom

Key Elements of National Space Strategy

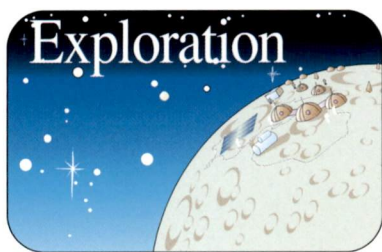
The Space Council's approach for implementing U.S. national space policy divides all space activities into five areas, each of which may encompass civil, national security, and commercial activities conducted by NASA, DOD, DOE, DOT, other government agencies, or the private sector.

The space program serves multiple objectives: preserving the nation's security; creating economic opportunity; developing new and better technologies; attracting good students to engineering, math, and science; and exploring space for the benefit of mankind. The Council's approach is designed to achieve these objectives as an integrated national effort cutting across traditional lines of civil, national security, and commercial programs.

The five key elements of U.S. National Space Strategy are:



1 To develop U.S. space launch capability — our transportation to and from space — as a national resource: the space transportation infrastructure will be to the 21st century what the great highway and dam projects were to the 20th. We will ensure that this infrastructure provides assured access to space, sufficient to achieve all U.S. space goals.



2 To open the frontiers of space through both manned and unmanned exploration: we will build on the successes of Viking and Voyager and proceed to comprehensively explore the solar system with Magellan, Hubble, Ulysses, and other ambitious unmanned programs. The President's call to complete Space Station Freedom, return to the Moon to stay, and the journey to Mars has finally given a much needed focus to our manned efforts. New ideas will be synthesized into varied approaches to undertake these premier space flight missions of the future.



3 To intensify our use of space in solving problems here on Earth: we already use space systems to verify arms control treaties and to provide our defense forces with warning, communications, navigation, meteorology, and other functions vital to our national security. Satellite communication networks link peoples around the globe and contribute to the increasingly successful fight against repression and totalitarianism. Remote sensing from space contributes to a variety of land and ocean use applications and helps us understand, and potentially mitigate, the process of global climatic change.

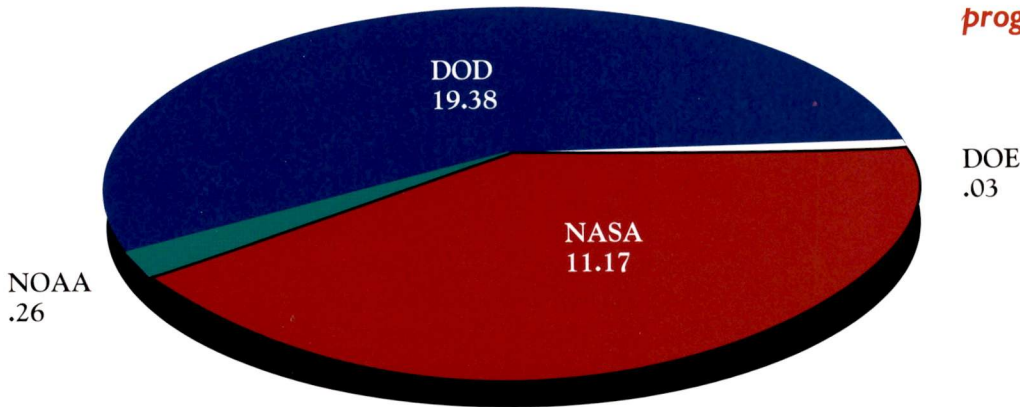


4 To foster our economic well-being: we will capitalize on the unique environment of space to investigate and produce new materials and medicines and develop clean and abundant energy for all. The resulting private investment will create jobs; boost the economy; and strengthen our science, engineering, and industrial base. Along the way, new commercial space markets will be created and existing industries will become stronger and more competitive in the world marketplace.



5 To ensure the freedom of space for exploration and development: there are currently numerous spacefaring nations, with many others on the way. Space will become to the future what oceans have always been — highways to discovery and commerce. But the sea lanes must be open to be usable, and as we know from past conflicts, they are subject to disruption. Thus, we must ensure the freedom to use space for exploration, development, and security for ourselves and all nations.

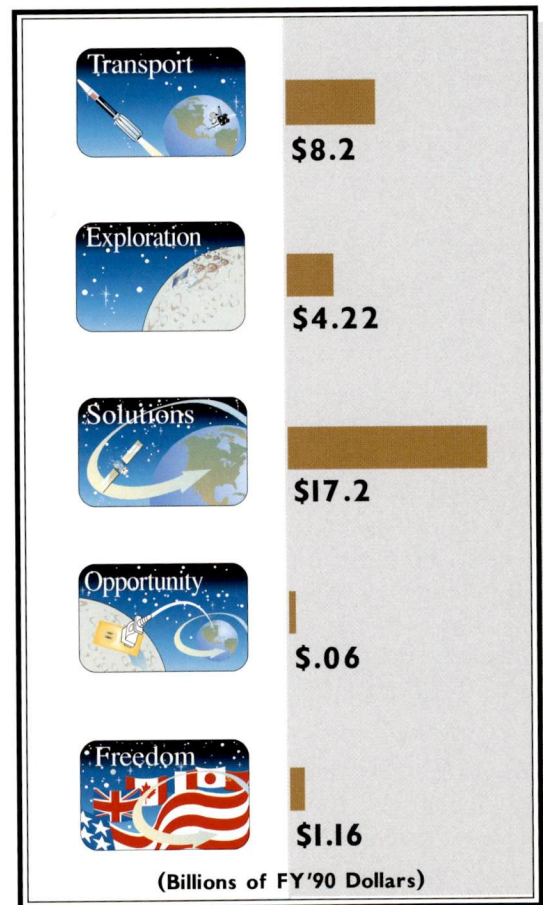
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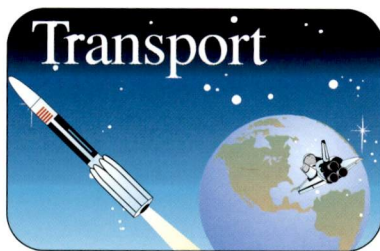


Resources for Space

The total U.S. Government spending on space related activities is over \$30 billion in fiscal year 1990. To put this in context, space spending is 2.5% of the almost \$1.2 trillion federal budget. Put another way, federal space spending is only one half of one percent of our \$5.5 trillion Gross National Product.

Most of the funds for space activities are divided between NASA and the Department of Defense as portrayed by the chart above. The chart on the right highlights the breakout of space expenditures according to the five elements of our U.S. Space Strategy. As can be seen, well over half of our space spending is directly devoted to solving problems on earth. The majority of the remainder of these funds is spent in developing our space launch infrastructure to place and operate these systems in space.





Developing Space Launch Capability and Infrastructure as a National Resource

The nation today has a substantial and diverse space launch capability, with human access to space provided by the Space Shuttle, and unmanned access by four families of expendable launch vehicles (ELVs). This "mixed fleet" is the result of a major shift in national space policy following the 1986 Challenger accident. The new policy provides encouragement to the young U.S. commercial space launch industry.

The Space Shuttle is currently the only U.S. launcher able to carry humans into space and is also our largest payload carrier to low Earth orbit. Further, it offers unique capabilities for the repair and recovery of payloads in space and the conduct of human-tended experiments. The current space policy limits its use to these functions which cannot be performed by other U.S. launchers.

Our ELVs are used for launches of civil, commercial, and national security payloads. Our nation's ELV history started out in the 1950s in support of our strategic defense needs and then progressed into meeting our nation's need for putting man into space. Upon completion of the Apollo missions and the emergence of the Shuttle, government transportation needs were to be shifted exclusively to the Shuttle, thereby phasing out ELV development and production for the government. In May 1983, the government endorsed and committed to facilitate the commercialization of U.S. ELVs. In February 1985, the President directed DOD to pursue an improved assured launch capability through procurement of a limited number of ELVs.

After the Shuttle accident, the President directed DOD to secure additional ELVs to maintain a balanced launch capability and the ELV production lines were resurrected in support of our national needs. Our current military ELV fleet carries many critical assets in support of our nation's communication, navigation, surveillance, and weather missions. There are two primary sites in which launch operations occur; Cape Canaveral (east coast operational center) and Vandenberg Air Force Base (west coast operational center). In support of these sites, critical launch and range infrastructure, such as ships, tracking sites, huge launch structures and their associated support equipment, and a city of support process buildings

(including ELV and payload assembly, fuel storage, hospital, and fire stations) remain essential. These facilities not only meet our national needs, but also support the emerging U.S. commercial launch industry.

Commercial ELV business had its beginning in the mid 1980s. Arianespace and several U.S. companies began their quest for payloads in order to assist in supporting the expanding commercial satellite demand and the subsequent backlogs prior to the resumption of shuttle activity. Although the U.S. commercial launch industry is still in its infancy, it has already become competitive in the international launch service market.



The Space Shuttle—reusable manned access to space



We are already embarked on what many scientists call the renaissance of scientific space exploration.

The existing commercial fleet, based on these government-developed vehicles, is now in the process of being supplemented by smaller entrepreneurial commercial launch and launch service providers. These new companies, which have had several flights, hope to establish a market niche for low-cost launches of small payloads.

Several state governments are looking beyond the provision of launch services to the development of commercial space-ports. Florida proposes using facilities at Cape San Blas and Cape Canaveral; Hawaii is examining the prospects for a spaceport to service small or medium launch vehicles; and Virginia is exploring the establishment of a commercial spaceport at the existing NASA launch facility on Wallops Island.

To meet the expected needs of civil, national security, and commercial space sectors, launch costs must drop significantly and the reliability, robustness, and lift capacity of our launch systems must increase. The Air Force and NASA are jointly pursuing research and technologies to support future decisions on an advanced launch system. The current focus of this program is on propulsion technologies and vehicle concepts, however, the propulsion technologies are being developed within the context of a potential family of launch vehicles which could be much less costly and more reliable than current systems.

The Delta Expendable Launch Vehicle—a commercial and government workhorse



Developing Space Launch Capability and Infrastructure as a National Resource

New Commercial Space Launch Policy

The Space Council recently completed a comprehensive review of commercial space launching which resulted in important new policy guidelines which will further encourage the growth of U.S. private sector space activities.

The commercial space launch policy recognizes the many benefits which a commercial space launch industry provides to the United States, to include indirect benefits to U.S. national security. It balances launch industry needs with important national security interests and with those of other industries and establishes the long-term goal of a free and fair market in which U.S. industry can compete.

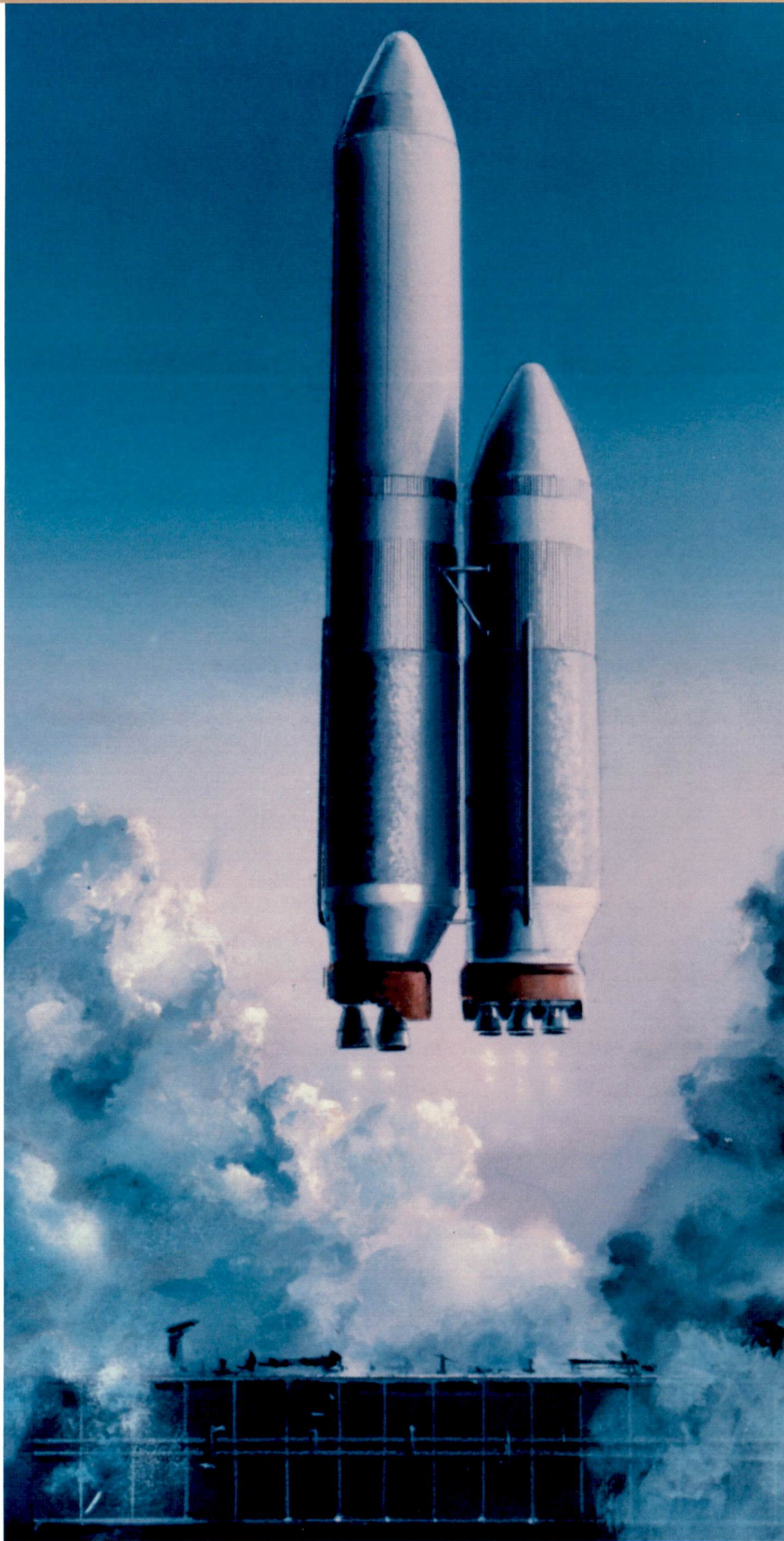
The policy specifies a coordinated set of actions for the next ten years aimed at achieving this goal. The elements of the policy will:

- Encourage technical improvements by directing U.S. government agencies to actively consider commercial needs and factor them into decisions aimed at reducing the costs and increasing the responsiveness and reliability of American launch vehicles.
- Foster free and fair trade through negotiations with the European Space Agency and other launch providers.
- Provide a framework for dealing with non-market economy launch providers and for considering the participation of the Soviet Union in the Western market for space launch goods and services.
- Ensure that all agreements are structured in such a way as to be enforceable.
- Further U.S. missile non proliferation and technology transfer objectives.

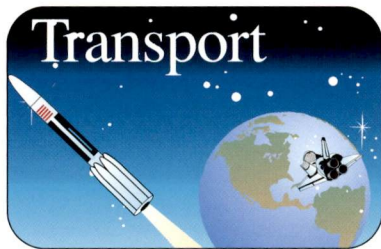
The Titan launch vehicle



The Atlas Launch Vehicle



*Artist's concept of the USAF/NASA
Advanced Launch System*



Developing Space Launch Capability and Infrastructure as a National Resource

The National Aerospace Plane

The National Aerospace Plane (NASP) program was first announced by President Reagan in the January 1986 State of the Union address. Its objectives were to develop and demonstrate hypersonic and single-stage-to-orbit technologies. The program has significant potential for national security and for furthering U.S. competitiveness and aerospace industry leadership in the twenty-first century.

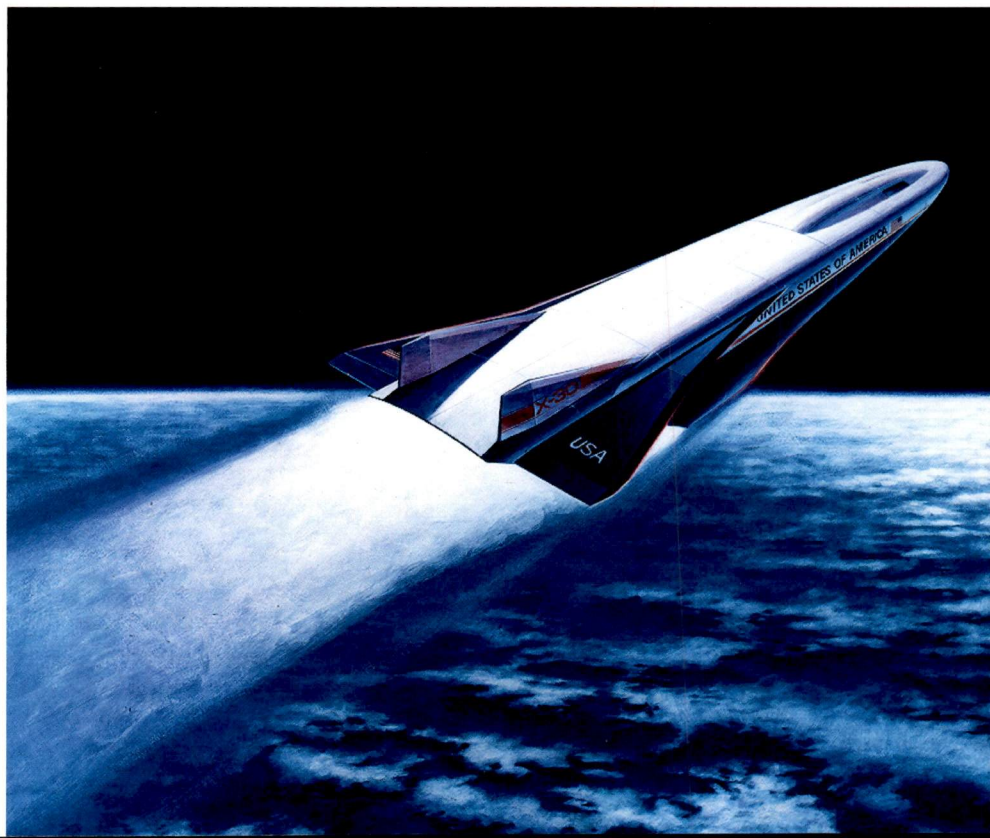
The program is structured in three phases: a preliminary technology and applications analysis, a technology development program, and then development and flight testing of one or two experimental flight vehicles, designated X-30. NASP has been jointly funded and managed by the DOD and NASA, who will have invested together approximately \$800 million through the end of

FY 1989. In addition to this government funding, U.S. aerospace corporations have invested a total of about \$550 million in NASP technology to date and are planning to spend a total of about \$750 million by the end of the program's technology development phase.

In April 1989, the Secretary of Defense, in developing his revised budget, asked the National Space Council to review the NASP program.

The Space Council conducted an interagency review which concluded that NASP will benefit civil, commercial and national security sectors, promote industrial competitiveness, and enhance U.S. space leadership. However, although the Council recognized the significant technical progress that has been made, it concluded that NASP

In April 1989, the Secretary of Defense, in developing his revised budget, asked the National Space Council to review the NASP program.



remains a technically challenging program and that its technology is not yet sufficiently mature to support a decision to proceed with operational vehicle design and development.

Acting on the Council's recommendations, the President approved the following policy:

"The United States will continue the NASP program as a high-priority national effort to develop and demonstrate hypersonic technologies with the ultimate goal of single-stage-to-orbit. The government will complete the Phase II technology development program and plans to develop an experimental flight vehicle after completion of Phase II, if technically feasible. Performance of the experimental flight vehicle will be constrained to the minimum necessary to meet the highest

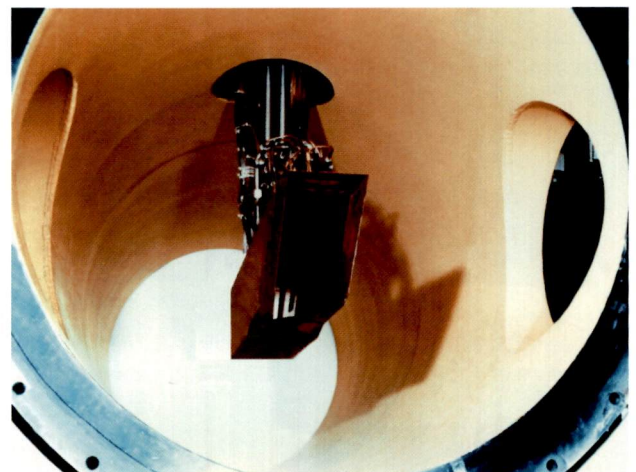
priority research, as opposed to operational objectives. Unmanned as well as manned designs will be considered, and the program will be conducted in such a way as to minimize technical and cost uncertainty associated with the experimental vehicle."

The President also approved retention of an appropriate joint DOD/NASA management structure, and asked the Space Council to review the program again prior to initiation of vehicle development. These actions set the NASP program on a sound course consistent with national policy objectives. He also directed that NASP funding be increased to the levels necessary to meet the policy objectives.

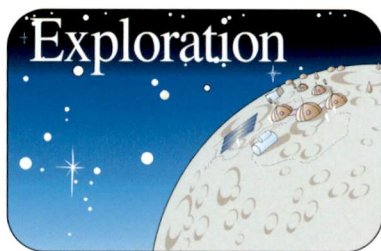


Titanium composite material fabrication

Supersonic combustion Ramjet Engine test

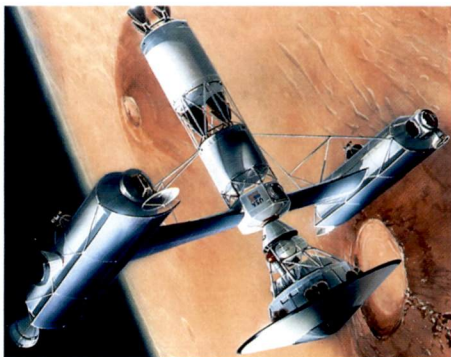
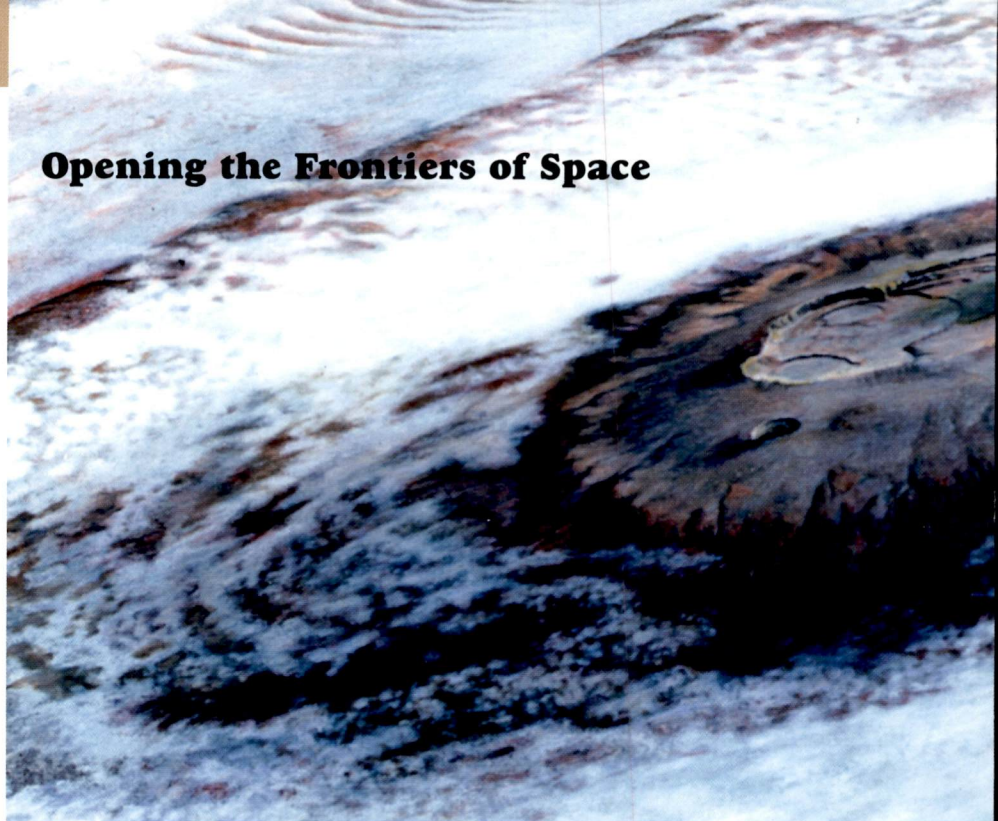


Concept of the NASP experimental prototype



The Space Exploration Initiative is the ultimate investment in America's future.

Opening the Frontiers of Space



Above: One concept for a manned Mars spaceship, featuring artificial gravity, Center: Lunar Lander

The Space Exploration Initiative was a major activity of the Space Council during its first year. When President Bush announced his long-range goals for human exploration of the Moon and Mars on July 20, 1989, he asked the Space Council to develop a strategy for achieving these goals.

Various detailed programs for permanent settlement of the Moon and the human exploration of Mars have been proposed for over 20 years as logical extensions of the capabilities we developed for Apollo and subsequent Earth-orbit operations.

The President's July 20, 1989 announcement firmly established the nation's long-range goals in the human exploration of space: to proceed from Space Station Freedom to a permanent lunar presence in the next century, followed by a mission to Mars.

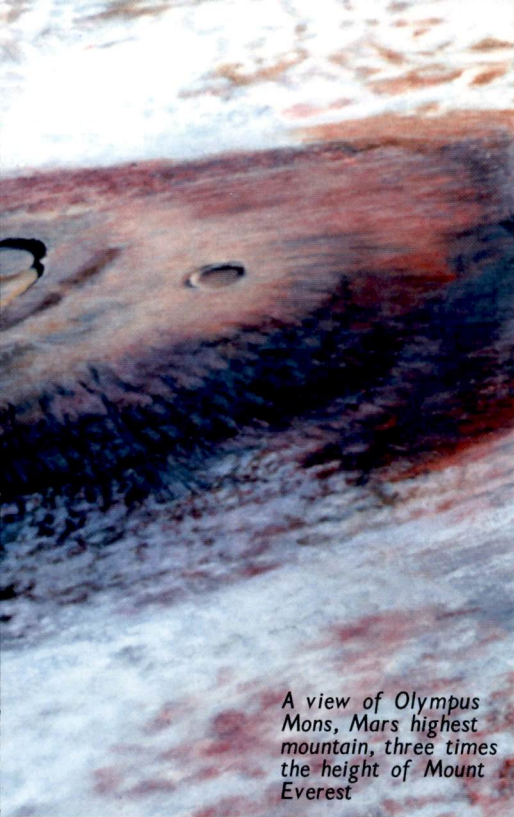
The Space Exploration Initiative is the ultimate investment in America's future. By responding to the human imperative to explore, we will reap benefits for ourselves and future generations akin to those of the voyages by Columbus and Magellan. We will increase our storehouse of knowledge about the planets, including our own,

and about the nature of life itself. We will develop new technologies, many of which will have applications that will improve our lives on Earth. We will stimulate science and engineering education in this country by inspiring and motivating our young people. And we will be setting the stage for eventual permanent human habitats on other planets. Moreover, the Space Exploration Initiative will improve our competitive technological position in the world while enhancing our national pride and international prestige. But most importantly, the technological capabilities we develop, the new resources we discover, and the new industries we find in pursuit of these ambitious space-exploration goals will power American economic pre-eminence throughout the 21st century.

The Space Council was charged by the President to define an approach by which his space exploration goals could be best achieved, including an assessment of the possibilities for international cooperation.

The Council received suggestions for implementing the initiative from NASA, the Department of Energy and industry firms. The Council also benefited from a review of these ideas by





A view of Olympus Mons, Mars highest mountain, three times the height of Mount Everest

the National Research Council. All concluded that the President's goals were achievable, but the suggested approaches varied widely. The Council decided that so ambitious a program would require a systematic search for innovative concepts and new technologies having the potential to reduce costs, accelerate schedules, and reduce risk.

The Space Council therefore recommended to the President that such a search be conducted and that the Initiative first focus on technology development. The Council also concluded that at least several years should be devoted to defining two or more significantly different program architectures and developing and demonstrating technologies broadly applicable to space exploration. The President accepted the Council's recommendation and on February 16, 1990 it issued a policy directive to that effect.

The decision also stated that the initiative be led by NASA and include a balanced program of robotic and manned exploration missions. To take maximum advantage of existing capabilities, however, the technological and systems expertise of other relevant agencies should be tapped. Therefore, the Departments of Defense and Energy

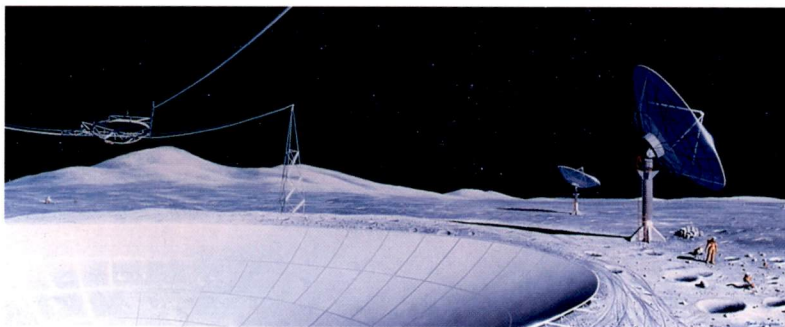
will play significant roles in technology development and concept definition and will continue to work with NASA to develop the SEI.

To define our technology development and architecture development programs, the Space Council has chartered an Exploration Outreach and Synthesis activity. Throughout the summer of 1990 a number of government agencies, professional technical organizations, federally contracted research centers, and private citizens developed ideas on the technologies and approaches which could enable us to accomplish our exploration goals faster, cheaper and better.

The ideas collected by the Outreach effort are being reviewed and analyzed by a Synthesis Group chaired by

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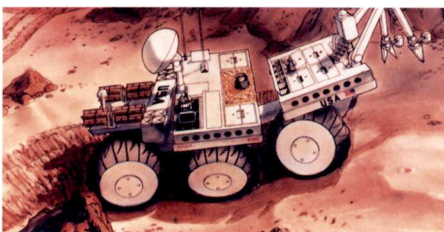
An artist's rendition of a large, man-tended radio telescope in a crater on the moon



Lieutenant General Tom Stafford (Ret.), former Apollo astronaut and distinguished space expert. This panel will report to the NASA Administrator and the Space Council in early 1991—recommending the alternative architectures and technology development course we should pursue over the next few years.

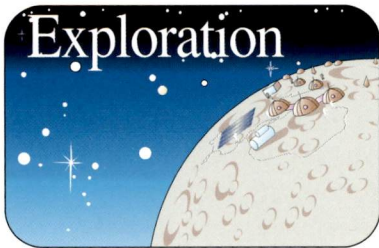
The Synthesis Group recommendations and the work to study the alternative architectures in the coming few years can shape the heart of our exploration effort. While we are not embarking on a costly development program now, these efforts will allow us to make informed decisions on how and when to proceed affordably and most effectively.

Concept for a Mars Rover



Concept for a commercial Lunar Outpost





Opening the Frontiers of Space

The traditional focus of our nation's space science programs has been to observe and understand the universe by accumulating scientific knowledge of the planet Earth, the solar system, and the universe beyond.

A prime objective of our future plans is to open the space frontier. To create the scientific foundation essential for planning and conducting missions to the Moon, Mars and beyond, we must collect data on the surfaces of the Moon and Mars and develop a thorough understanding of the long-term effects of the space environment on human beings.

A particularly exciting facet of the Space Exploration Initiative is the opportunities it will offer to explore the surfaces of the Moon and Mars and use them for scientific purposes. The Moon, for example, might be an ideal location for next-generation space observatories.

We are already embarked on what many scientists call the renaissance of scientific space exploration. Beginning in May 1989 with the departure of the Magellan spacecraft to Venus, we have launched eight successful space science missions in the past two years. As of October 1990, three solar system

exploration missions — Magellan, Galileo, and Ulysses — had begun. The Hubble Space Telescope was deployed. The Cosmic Background Explorer (COBE) had successfully examined the background radiation of the cosmos, collecting data that could change our theories about the universe's early history. And several space physics missions had been carried out. We plan to launch an average of five or more space science missions annually through 1996. During the next few years we will expand our knowledge of the universe more rapidly than at any other time in human history.

Space Station Freedom

Space Station Freedom is a major milestone in our planning for the future. This permanently occupied orbiting base will help to maintain U.S. space leadership into the 21st century. It will play a vital role in science, exploration, and space commercialization.

Freedom will provide a world-class multidisciplinary laboratory in space for life sciences and materials research which simply cannot be done on Earth.

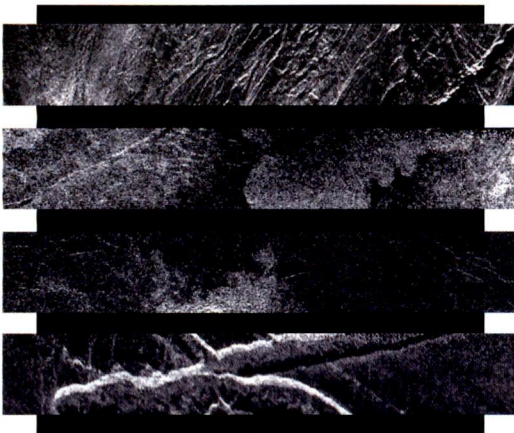
It will support instruments to look out at the universe and back at the Earth, including those which will help us understand the threats to Earth's global environment.

Freedom offers a unique facility for developing new technologies, products, and processes. Among the exciting possibilities are the development of new pharmaceutical methods and processes and treatments for serious diseases.

Research on Freedom will help prepare humans for the long-duration space missions of the Space Exploration Initiative.

Freedom could also lead to further international cooperation with nearly one third of the initial investment in the station being borne by our partners in Europe, Japan, and Canada. The agreements signed by Freedom's participants form a possible framework on which to build forthcoming cooperative programs in mankind's exploration of space.

In summary, Freedom will be an important element in opening the frontiers of space, in attracting new private-sector users of space in such industries as advanced materials and medical products, and in forging closer bonds with our international partners.

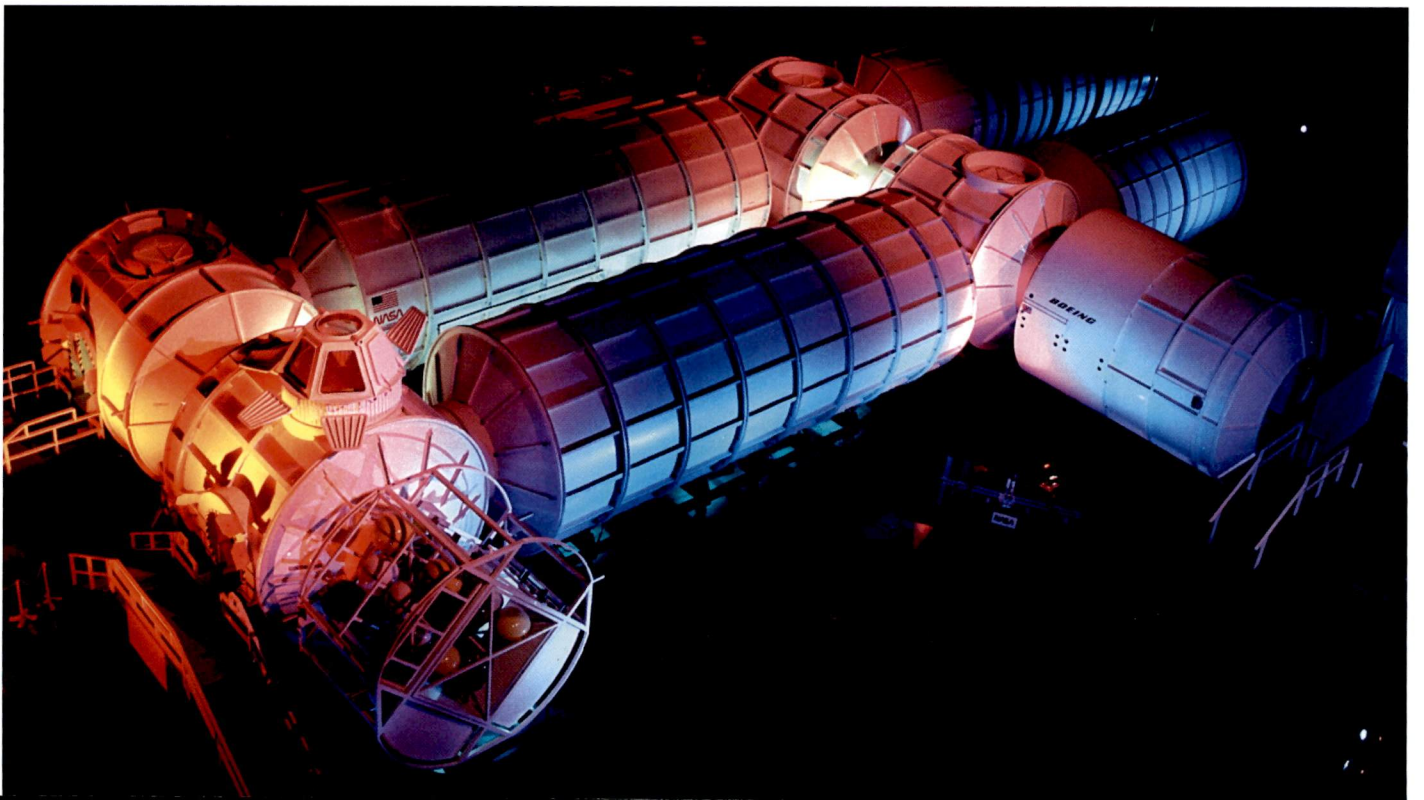
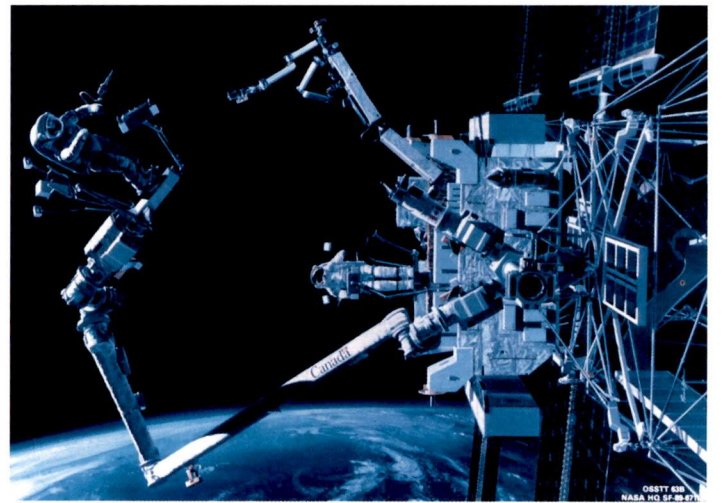


*Images of Venus from
Magellan spacecraft*

*Above Right: a view into the laboratory
module of Space Station Freedom,
Center: robots and crews will team up
for assembly and servicing on Space
Station Freedom, Below: the Space
Station Freedom modular concept*



Freedom will be an important element in opening the frontiers of space, in attracting new private-sector users of space in such industries as advanced materials and medical products, and in forging closer bonds with our international partners.



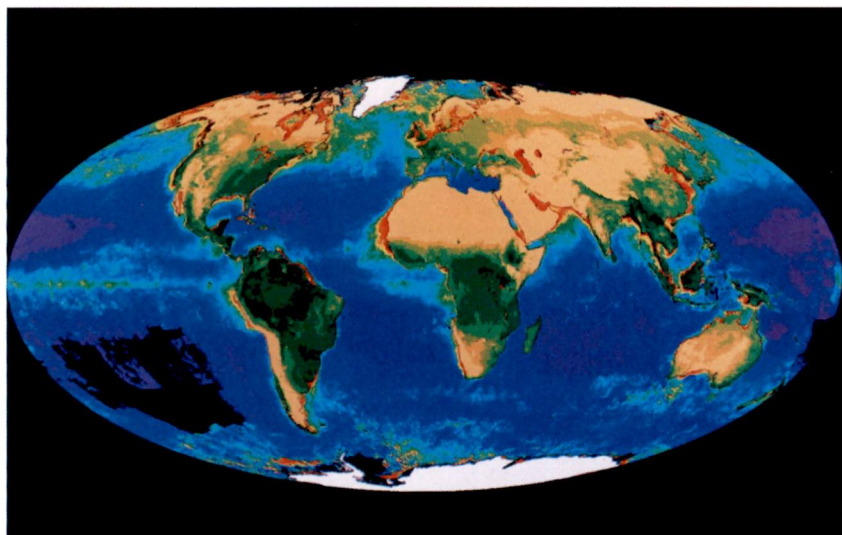


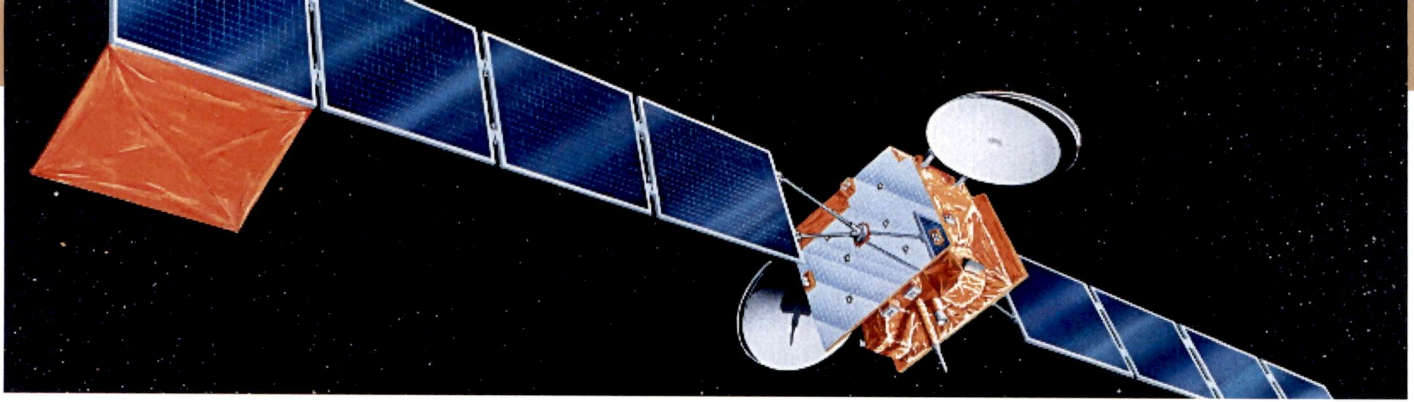
Using Space to Solve Problems on Earth

Space already meets many modern day needs. It has been used to improve the quality of life for Americans by creating new communications, navigation and other services that knit people and businesses more effectively than ever before; by observing the Earth from the unique vantage point of an orbiting satellite; by applying the results of space biomedical research; and by preserving the peace and security of the U.S. via satellites for surveillance, treaty verification, communications, and navigation. In the broader context our space efforts help people everywhere by fueling the world's economic engines; advancing human health through life sciences research; improving communications around the globe; and using the global perspective of space to observe and predict weather and ultimately to assess and ameliorate changes in our global environment.

Mission to Planet Earth

This facet of the use of space is of particular importance. In recent years we have become aware that human actions can affect the environment on a global scale. "Mission to Planet Earth" is a program that focuses our capabilities for satellite remote sensing to help us understand how the Earth works as an integrated system. Its centerpiece is the Earth Observing System (EOS), a fleet of satellites which will provide comprehensive, long-term observations of the whole Earth and its component parts. EOS is a particularly important issue for the National Space Council because it is an effort that cuts across many agencies, such as OSTP, NOAA, EPA, and NASA. The primary goal of these observations is to serve as the basis for developing and refining predictive models of our planet that can be used to formulate policies for reducing any negative effects of long-term changes in the Earth's environment. Because such policies could have major economic impacts, it is extremely important that the predictive models be as accurate and comprehensive as possible. The Space Council plans to build on a National Research Council (NRC) assessment to address the policy issues inherent in implementing the EOS satellite system and its ground support components.





Space Medicine

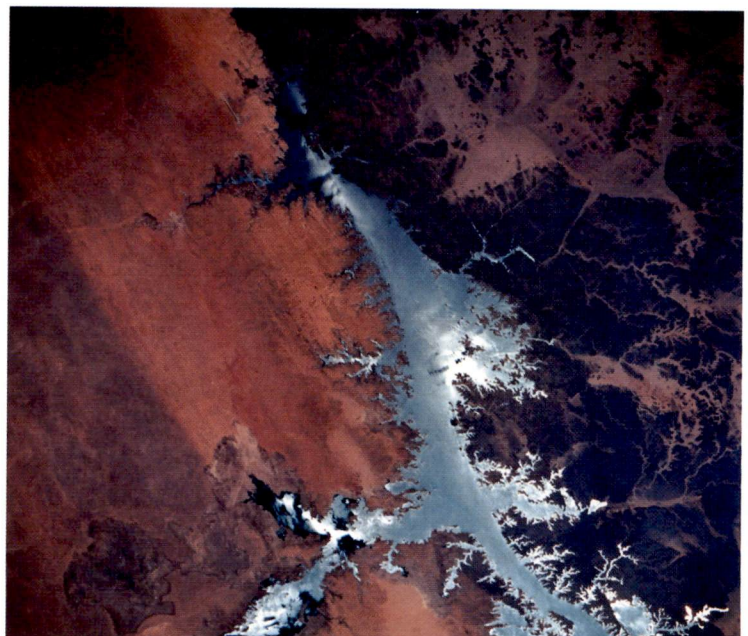
Research conducted to ensure astronaut health and safety also benefits the health and well-being of people on Earth. Advances made in space medicine have been applied to detecting, diagnosing, preventing, and treating medical conditions everywhere. New and improved surgical techniques, devices, and medicines have also been developed as the result of space research. The biological and medical research needed for human space exploration will greatly expand our knowledge base and potential for medical breakthroughs for people on Earth.

Satellite Communications

Global communications initiated the world's commercial use of space. Improving and expanding on space-based communications capabilities and services have high priority on the Space Council agenda. Research for space missions is often applied to increase the capacity and flexibility of terrestrial telecommunications services such as live overseas television transmissions, trans-oceanic phone calls, and worldwide data networks. The Space Council is in the midst of a policy review to determine how the federal government can best foster an environment conducive to the growth of communications and other commercial space service industries.



*Left: Global Biosphere, Bottom Right: Nile River, Top Right: artist's rendition of communications satellite
Right: the Strategic Defense Initiative will provide technology for strengthening deterrence—solving problems on earth*





Satellite communications and navigation have become an integral part of every kind of military mission.

Understanding how to grow food in a closed environment



Using Space to Solve Problems on Earth

Microgravity Science

Microgravity research is aimed at attaining a structured understanding of gravity-dependent physical phenomena in areas such as materials science, combustion science, and biotechnology. Ultimately, microgravity research may lead to our improving solid-state electronics and semiconductors, developing new medicines and vaccines, creating metal alloys and composites having unique properties, and developing new instruments and laboratory techniques. The microgravity environment of the Shuttle and some suborbital vehicles are currently being used to make small research quantities of highly valuable materials during short duration flights. The space station would allow more extensive research. The Space Council has reviewed plans and directions in these programs to ensure that our policy provides the maximum opportunity for developing new industries and services.

The Landsat Policy Decision

One of the first tasks undertaken by the National Space Council was a review of the Landsat program.

NASA pioneered civil Earth remote sensing with an Earth Resources Technology Satellite launched in 1972 (later renamed Landsat 1). Subsequent Landsats demonstrated this technology and its applications so successfully that it was declared to be operational, and program management was transferred from NASA to the Department of Commerce with the intent of effecting transition of the entire program to the private sector.



During the past few years, however, it became increasingly evident that privatizing Landsat would not be commercially feasible for a long time. Actual market experience discredited the unrealistic revenue expectations on which previous studies had been based. But since government planning was predicated on commercializing the entire program, this lack of near-term commercial viability threatened the continuity of Landsat data, which had become valuable to its users, many of which were U.S. Government agencies. The Space Council was asked to revisit existing government policy in light of current, more realistic projections of revenue growth and the importance of federal applications for Landsat data.

The Council's full interagency review revealed that government agencies, not the private sector, do indeed account for the great majority of Landsat data sales.

The Council found that Landsat is an important, but not critical, source of data for such civilian agency applications as environmental monitoring, global change research, economic intelligence, and law enforcement. The Landsat program is utilized by 12 nations (and the European Space Agency) which paid for and now uses Landsat ground stations.



The federal agencies, in aggregate, believe that U.S. national interests are well served by a continuation of Landsat-type data.

Based on these findings, the Space Council recommended and the President approved the policy that, "The U.S. is committed to ensure the continuity of Landsat-type remote sensing data to meet civil, commercial, national security, and foreign policy needs." The President approved government funding for the continued operation of Landsat satellites 4 and 5 as well as funding to complete and launch satellite number 6 in 1992.

National Security

The national security space sector is a major provider and user of space systems across a wide range of applications. For example, the importance of space to national security was clear in support of our military operations in Panama and space systems continue to prove their value daily in support of Desert Shield. Although security considerations prohibit going into detail, the absolute necessity for and importance of space in safeguarding our national security must be unequivocally recognized.

Space Systems are a major source of missile early warning for the nation and its strategic forces and also support tactical operations worldwide. Satellite-derived information also forms the cornerstone of U.S./U.S.S.R. arms-

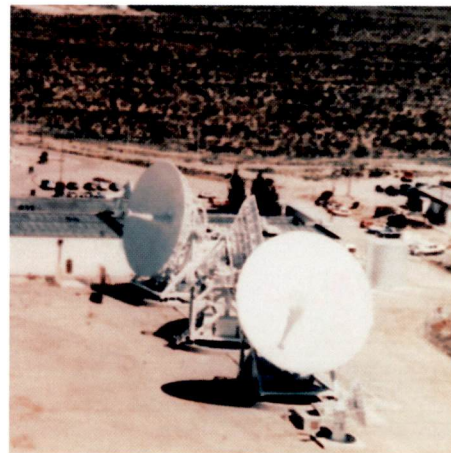
control treaty monitoring, and contributes to global stability by reducing the possibility of surprise developments, thereby allowing time for crises to be averted.

Satellite communications and navigation have become an integral part of every kind of military mission. The worldwide coverage needs of military functions make them ideally suited for support by space systems. The navigation capability established for the military is also used routinely and widely in civil applications. Meteorological satellites provide critical weather information in support of world wide military operations. While this application is primarily defense-related, close coordination is maintained with civil weather satellite programs. As an example, the Defense Meteorological Satellite Program has proven invaluable in tracking hurricanes in both the Atlantic and the Pacific. Space may also be used in the future for defensive measures as in the case of ballistic missile defense.



Long Term Impacts

In the next century, our Planet's resources will be increasingly taxed. Growing demands for energy, raw material and finished products cannot be met without serious environmental impact. While no one can accurately predict how space can help provide for earthly needs, space holds significant promise for new sources of energy, material and products. As we come to understand the complex interplay of man-made and natural effects on the environment, space may play the crucial role in correcting damage which has already occurred and prevent future problems. Space might provide unlimited, clean sources of energy. Resources and manufacturing in space may be provided without environmental damage. We might even be able to intervene to correct environmental problems from space.



Above Right: Washington, D.C. as seen from Landsat, Above Left: Astronaut "Pinky" Nelson tending a crystal growth experiment Above: Large communications satellites link all nations across the globe, Right: Satellite ground terminals are the gateways for the global village



The real benefit of space to the economy will be in the creation of new technologies, new products, and new services.

Generating Economic Well-Being

Creating New Industrial Capability and Jobs

The emergence of a separate, non-governmental commercial space sector, whose importance is explicitly recognized by the National Space Policy, holds the promise of generating enormous benefits for the nation. Already, according to the latest edition of *U.S. Industrial Outlook, 1990*, "...commercial space sector revenues are expected to increase to \$3.3 billion in 1990 from \$2.6 billion in 1989... The underlying rate of growth is 10%, and most of the revenues are generated by satellite-related activity. New satellite services for business are expanding rapidly... All areas of space commerce are facing increased international competition."

Opportunities for commercial enterprises exist in:

- ground-based infrastructure support
- commercial launch services
- space insurance
- space law
- telecommunications satellites (construction and operation)
- remote sensing satellites (satellite development and data analysis)
- position location satellites

- materials research and processing in space
- space-based industrial facilities
- payload processing services
- spaceport safety management
- financing services
- commercially developed launch facilities

Of these, the space communications industries are the most mature and fastest growing. 1990 revenues from all sectors of the international satellite communications market were estimated to be in excess of \$5 billion. Although the international arena is increasingly competitive, U.S. satellite manufacturers continue to produce the majority of the world's communications satellites, exports of which are estimated at \$1 billion this year alone. Ground station equipment and terminals for sending and receiving satellite signals is the fastest growing satellite-related industry and shipments are expected to increase to \$850 million in 1990 from \$750 million in 1989. The United States is a net exporter of satellites, which have among the highest "value added" of all products built domestically.

One of the most promising developments in space communications is the "lightsat". Using new technologies in sensors, electronics, and computers, a lightsat weighing a few hundred pounds or less might do the job at much less cost. Such satellites might also be launched on a new generation of small launch vehicles. The United States leads the world in developing lightsats and small launch vehicles.



Geostar navigation system in truck cab

Utilization of Space Technology

The second largest commercial space sector is in spacecraft launch services. For the period of 1990-1993, the Department of Transportation's Office of Commercial Space Transportation — which licenses and promotes commercial space transportation activities — estimates that the U.S. launch service industry will generate \$640 million in 1990, with annual revenues of at least \$450 million expected over the next several years. Known commercial launch contracts from 1990 through 1995 currently exceed \$1.9 billion, and \$1.4 billion are for customers other than the U.S. Government. One major U.S. launch supplier estimates that approximately 20,000 prime contractor and major subcontractor jobs are affected by U.S. commercial space transportation activities. In addition, U.S. commercial space launch companies report that they have invested over \$700 million to date.

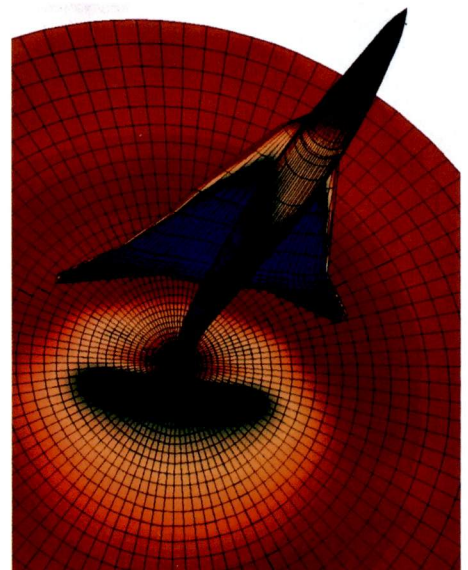
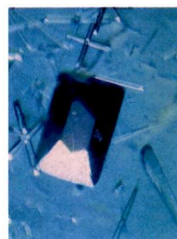
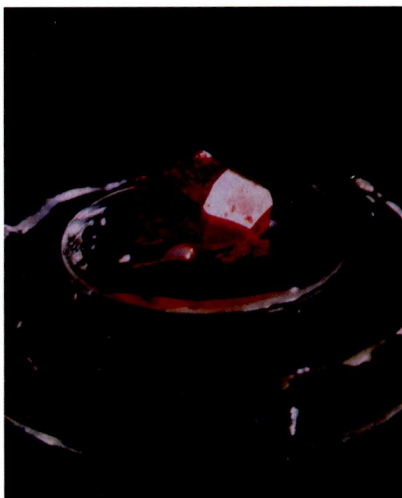
The government contributes to the space economy by being a customer for private-sector goods and services. Because of their often unique or demanding requirements, government purchases can stimulate expansion of the market and the industry, thus creating jobs and generating revenue. An excellent current example of this practice is government purchasing of commercial launch services.

For the long-term no one can predict which industries will emerge from our space efforts. However, we might get our energy from space, find and extract resources, manufacture medical products and treatments to cure dreaded diseases, and produce materials using the unique attributes of space. There is also significant potential for the development and use of space technology for non-space commercial uses. We are on the threshold of a second great era of exploration — the expansion of human presence into the solar system.

As with the great age of exploration which began 500 years ago, we cannot imagine completely the scientific and industrial riches and benefits we will find.

The real benefit of space to the economy will be in the creation of new technologies, new products, and new services. For example, hundreds of companies are currently investigating ideas for new space-related commercial enterprises through NASA's 16 Centers for the Commercial Development of Space (CCDS). These consortia of government, academia, and industry focus market-driven research on those technologies most viable for commercial development.

Right: a perfect crystal grown in space of mercuric iodide, Center: crystal growth in process Far Right: super computer aircraft imaging





Generating Economic Well-Being

Strengthening the Industry Base

The National Space Council is conducting a comprehensive policy review to develop guidelines to most effectively encourage federal government efforts to support commercial space sector activities. The goal of these guidelines is to minimize unfair competition between the government and the emerging commercial space sector and to encourage an environment conducive to the ultimate development of new commercial, nongovernment-dependent space markets.

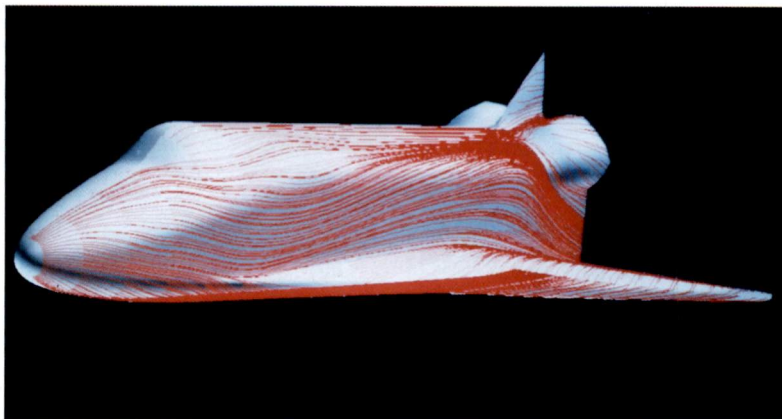
At the same time, these guidelines are intended to encourage innovative efforts by agencies, such as NASA, to continue developing innovative working agreements with the private sector to share costs and risks and give the commercial space sector, as appropriate, access to government facilities and other capabilities. Also, the Centers for the Commercial Development of Space program is a growing and dynamic initiative which currently involves 56 universities and 189 companies, and helps move emerging technologies from the laboratory to the marketplace by leveraging a broad industry base to

develop product-oriented technologies. This experience and emphasis on innovation should enable U.S. firms to compete more effectively with their foreign counterparts. A healthy business environment is encouraged through a consistent and predictable regulatory program managed by the Department of Transportation's Office of Commercial Space Transportation.

Technology Development

A sound technology base is the fundamental element upon which commercial markets, and, ultimately, new industries, are built. Although the goal of federal space policy is to build a commercial space sector which is not dependent on government support, the government can be very effective in helping to build the requisite technology base.

This role was recognized in the National Space Council's Commercial Space Launch Policy which directs government agencies to "actively consider" private sector needs when making decisions on improvements in

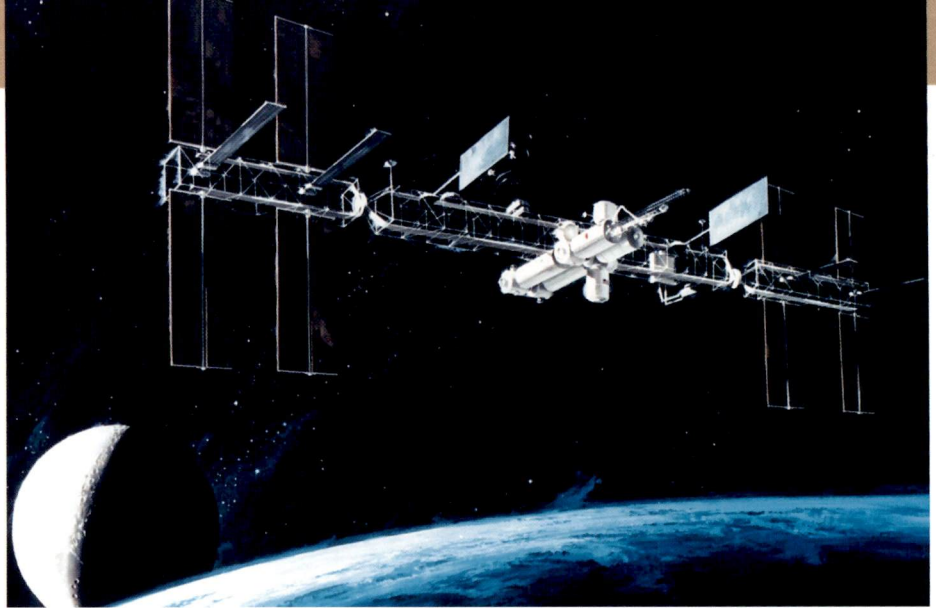


launch infrastructure and increasing reliability and responsiveness of space launch vehicles.

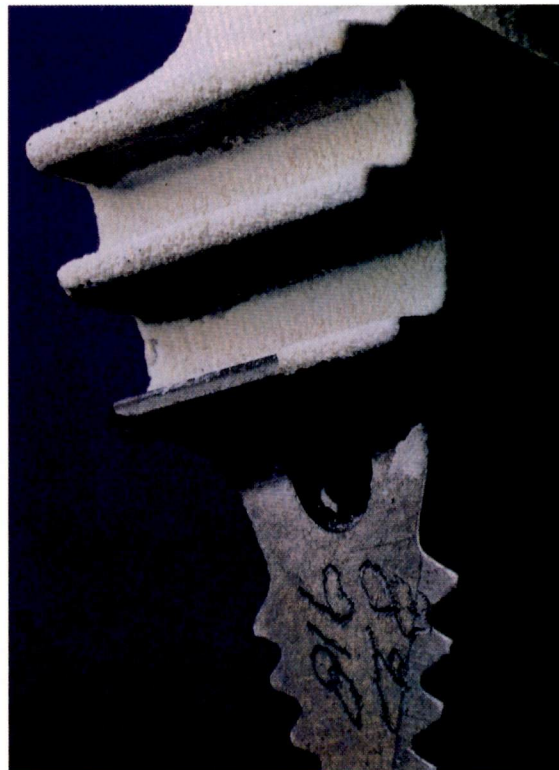
NASA is developing technology for direct commercial application in several areas. For example, the Office of Commercial Programs is sponsoring research into commercial remote sensing technology at the John C. Stennis Space Center.

The Office of Commercial Programs is also proposing an innovative project called the Commercial Experiment Transporter (COMET) which is designed to stimulate the growth of a commercial space sector able to prepare, launch and retrieve small space payloads developed by the various Centers for the Commercial Development of Space.

The Department of Defense also operates an extensive science and technology complex which significantly contributes to space technology development. For example, the Defense Advanced Research Projects Agency played a major role in providing seed funding, developmental assistance, and contracts for launch services which led to the successful April 1990 launch of the Pegasus launch vehicle.



Space Station Freedom will be a laboratory for technologies and products useful on Earth



Left: supercomputers allow design of advanced aircraft with less wind tunnel testing, Right: Close-up photo of thermal barrier coating for advanced engines



Ensuring Freedom to Use Space for Exploration and Development

We already know that space will play an increasing— if not dominant role in the global 21st century economy. While we hope and will work strenuously for a safer world and safer outer space environment, the very fact that space is an economic wellspring makes it a potential area for confrontations. The best way to avoid those confrontations is to have the means to prevent them, and if they occur, have the ability to deny an aggressor the fruits of his aggression. For these reasons, we must have the means to protect assets of ours and other nations.

To protect the freedom of space we need to be able to do three things.

First, we must be able to see and monitor all that occurs in space. While we have long-standing needs and systems to track objects in space — the United States now tracks over 7000 objects in space —we will need substantial improvements in these capabilities in the years ahead.

Second, we must develop the capability to protect our nation's space assets. This protection may take the form of passive measures to enhance the survivability of critical space systems and to

warn of attacks upon space assets. In that regard, we must be able to alert and warn owners and operators of space systems that threats exist. This means we must improve our technical abilities to quickly and reliably characterize the purposes of space activities, and we must be able to communicate warnings rapidly to those who can mitigate developing threats.

Third, we must develop the capability to intervene to protect our space and terrestrial (land, maritime, and air) operations that may be threatened by enemy space assets. We must be able to employ active measures, e.g., antisatellite systems, to stop an aggressor before he can use his space systems to threaten objects or people in space or on the earth.

Access to space can be denied by many means, including antisatellite attacks on space systems and sabotage of ground segments. The Soviet Union has an operational antisatellite system deployed. The U.S. has advanced technology applicable to antisatellite weapons and research programs.



The Defense Satellite Communication System provides global command and control information to U.S. forces deployed worldwide



Command Centers operate 24 hours a day to assess air and space activities around the globe



Space is very much like the ocean: freedom of traverse is necessary for international commerce and in some instances vital to the national security of some nations. As has happened on the seas in the past, some nations may choose in future conflicts to deny potential adversaries the use of space.

Worldwide ground radars are the mainstay for detecting and tracking satellites

Current and Planned Activities

The purpose of the Council's review is to define policy and strategic alternatives for the U.S. commercial space launch industry.

Commercial Space Policy

In March 1990, the Council assembled an interagency working group to review the implementation of commercial space policy. The purpose of the review is to assess the status of the emerging commercial space markets; to see how well the National Space Policy was working in this area; and, where appropriate, to develop additional policy and implementation guidelines.

The policy review will develop a working definition of commercial space activities; identify the various ways in which the government interacts with the commercial space sector (e.g., purchase of goods and services, transfer of technology, research and development, advocate free and fair trade) and seek to develop policy guidelines within which agencies would respond to commercial space sector initiatives. Such a policy framework would greatly increase the level of certainty and predictability associated with the private sector's interaction with the government.

The goal of this interagency assessment of commercial space, the most comprehensive ever undertaken, is to ensure that the government takes appropriate steps necessary to create an environment conducive to the formation of new space markets and industries, rather than merely expanding the commercial sector's capacity to supply government needs.

Space Transportation Policy

The National Space Policy identifies access to space as a key element in all U.S. space activities. It states that U.S. space transportation systems must provide a balanced, robust, and flexible capability with sufficient resiliency to allow continued operations despite failures in any single system. The policy identifies the following goals for the nation's space transportation infrastructure:

- (1) to achieve and maintain safe and reliable access to and from space and transportation within it;
- (2) to use both piloted and unmanned launch and recovery systems in a manner which exploits the unique attributes of each;
- (3) to encourage the development and use of private-sector space transportation as much as possible (President Bush recently announced the National Transportation Policy which encourages the use of commercial space transportation services for government space missions to the fullest extent possible); and
- (4) to reduce the costs of space transportation and related services.

The National Space Council is conducting a review to see how effectively these provisions of the U.S. policy are being implemented, and is also developing a comprehensive national space launch strategy. The review is being conducted in three phases:

Phase I will:

- Describe current and planned launch capabilities (e.g. performance, capacity, adequacy of infrastructure support, resilience to launch failure, etc.)
- Identify space launch needs, separating: 1) firm requirements associated with continued operation of existing space programs and other funded programs 2) projected needs for programs or missions which are



Pegasus being launched



Results of the Council's analysis will be incorporated in a comprehensive space launch strategy to guide future government actions.

under consideration but have not yet been approved or funded, and 3) projections of commercial launch needs.

- Compare current and planned space launch capabilities with these space launch needs and identify mismatches, if any.

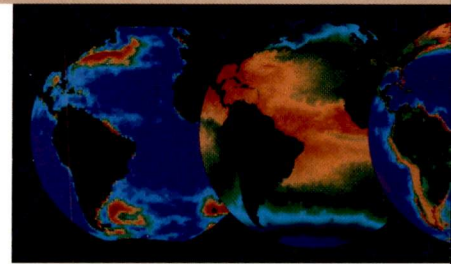
Phase 2 will identify and analyze alternative government actions to resolve mismatches and meet U.S. space launch objectives, such as:

- Additional policy guidance, if needed.
- Development and acquisition of new systems or infrastructure.
- Investments in research and technology, including the government's role, if any, in development of technology for commercial application.
- Investments in advanced ("leapfrog") technologies which offer the potential for large improvements in cost, performance or reliability.
- Modifications to procedures which might reduce launch costs or increase launch capacity.

Phase 3 will assess all combinations of these policies, procedures and investments, including appropriate revisions in agency management structures or in the current assignment of space launch roles and missions. Results of the Council's analysis will be incorporated in a comprehensive space launch strategy to guide future government actions.



Left to Right: The Space Shuttle, The McDonald Douglas Delta, Orbital Sciences Pegasus, Sounding Rocket for Research, The General Dynamics Atlas, The Martin Marietta Titan Above Right: Artist's conception of the USAF/NASA Advanced Launch Vehicle



The Space Exploration Initiative

The Space Council's activities in this Initiative were described in some detail earlier. The Council believes SEI is central to our future in space, and will maintain a continuing dialogue with the Congress, NASA, universities, industry, and federal laboratories on their activities dealing with this initiative.

International Cooperation

The Council explored the feasibility of international cooperation in the Space Exploration Initiative in parallel with establishment of a program policy. This interagency review examined past experience in U.S./foreign space program collaboration, capabilities of foreign spacefaring nations, the benefits and risks of international cooperation, and various options for the President to

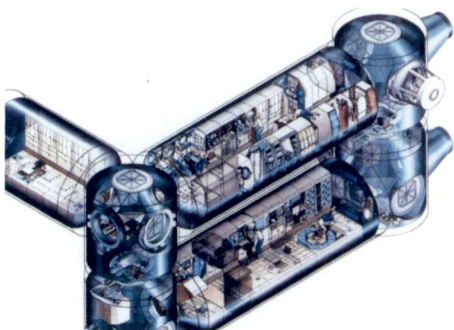
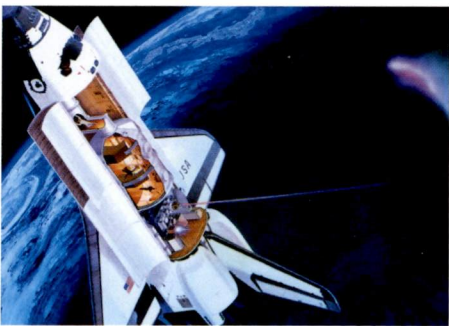
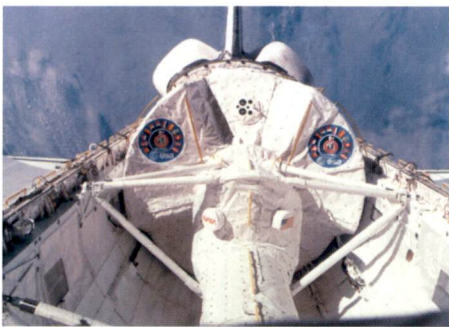
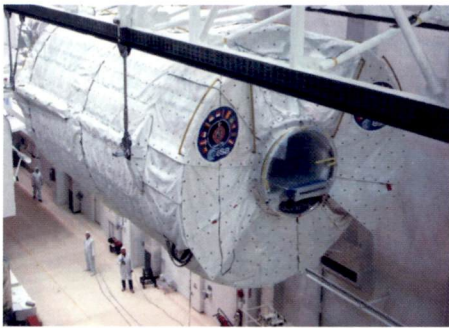
consider in deciding on the U.S. approach.

The Council concluded that the Space Exploration Initiative will be of profound significance to all mankind; and that international cooperation in this endeavor is feasible and could offer significant benefits to the United States.

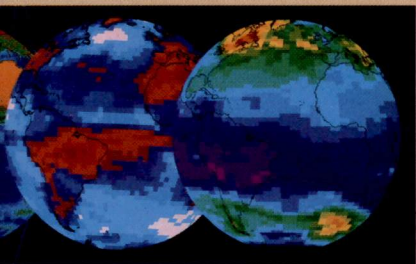
Acting on the recommendations of the Vice President and the National Space Council, the President announced on March 30, 1990, that:

- The United States will take a sequential and orderly approach to decisions on involving specific countries consistent with decisions made on the overall Space Exploration Initiative.
- The United States will seek an exploratory dialogue with Europe, Canada, Japan, the Soviet Union, and other nations, as appropriate, on international cooperation on the Initiative.
- The exploratory dialogue will focus solely on conceptual possibilities for cooperation.
- The dialogue will be based on guidelines expeditiously prepared by the National Space Council, and will be consistent with the National Space Policy.
- The National Space Council will ensure interagency coordination and review during the development of international cooperation on the Initiative, and provide recommendations to the President as appropriate.

The Space Council has now convened a working group on the guidelines for exploratory dialogue.



Left from top: Space lab module being serviced, Shuttle bay showing international space lab module, artist's rendition of materials processing module in shuttle bay, space station module interior, Above: Canadian robotic arm



The Earth Observing System—the window into the environment

Mission to Planet Earth Policy

Concern about environmental change is high in people's minds throughout the world. To respond to this concern, U.S. scientific agencies have begun the U.S. Global Change Research Program (USGCRP), whose objective is to understand, model, and predict changes in our planet's environment. The predictive models developed by the USGCRP can form a basis for policies to mitigate harmful environmental changes and prevent future problems from developing. A critical element of this program is NASA's Mission to Planet Earth (MPE).

MPE's objective is to collect the data needed for the USGCRP's climate models. The program includes both small satellites (known as Earth Probes) and large Earth Observing System (EOS) satellites, as well as suborbital observation techniques. EOS currently plans for six satellites over 15 years, with two in orbit at any given time, to be launched starting in the late 1990s. In addition to the two U.S. EOS satellites and replacements, the European Space Agency and the Japanese will each launch one environmental monitoring satellite and follow-on replacements.

EOS represents a major commitment of resources over 20 years. It will be the largest scientific program ever undertaken by NASA. EOS is a 1991 new start.

Because of the central role played by EOS in the USGCRP, the National Space Council has begun an in-depth study of the program. The objective of this study is to ensure that EOS and other space-data collection and analysis systems will provide the USGCRP with the most timely and cost-effective

support possible. The Space Council tasked the National Research Council to respond to the following questions:

(1) Does EOS collect the environmental parameters that are reflected in the USGCRP research priority framework?

(2) EOS is premised on the assumption that it is essential to collect data on various environmental parameters simultaneously. How important is data simultaneity to the ultimate utility of the data? Can the requirements for simultaneity be applied more narrowly than proposed?

(3) Depending on the outcome on the question of simultaneity, are the EOS platforms, as currently configured, the optimum means for collecting this data, or are there better alternatives that are more cost-effective or timely? These alternatives could include, for example, smaller multiple platforms flying in formation or additional near-term precursor missions that are capable of flying subsets or preliminary versions of EOS instruments.

(4) Does the proposed EOS Data Information System represent the appropriate approach to support the long-term data collection and monitoring effort? (EOS will produce a data flow at least ten times larger than any previous space or ground system).

The National Research Council has provided its input on these questions. The Council endorsed the EOS program, indicating it was responsive to the USGCRP research priorities. The NRC also agreed with the need to collect certain data simultaneously, and supported the requirement for at least

one large observing platform. Finally, the Council assessed and endorsed the proposed EOS Data Information System approach. The Committee on Earth and Environmental Science (CEES), a part of the Federal Coordinating Committee on Science, Engineering and Technology (FCCSET), is examining the NRC report on the EOS program in the context of the total USGCRP.

EOS represents a major commitment of resources over 20 years. It will be the largest scientific program ever undertaken.

Summary and Conclusion

The National Space Council is evaluating alternative strategies for using space to benefit mankind. Council activities have focused on validating, expanding and articulating the National Space Strategy and extending its guidance to specific opportunities throughout the space community.

Our efforts are guided by several specific principles. First, the United States plans to develop and pursue its opportunities in space. Space exploration and the application of space technologies is as much an imperative for the continued development of the nation as was exploration of the continent by our forefathers. America's future is inevitably and irrevocably linked to our efforts in space. This reality underlies the Council's sense of urgency in approaching its tasks.

Second, one of the greatest strengths of this nation is its ability to meld the efforts of its technological, industrial, academic, and governmental institutions toward a common cause. The Council's policies and plans for space capitalize on this strength by seeking to map a course that harnesses the innovative, creative and analytic





pro prowess of all American institutions. Consequently, the Council treats each goal, each objective, and each initiative as a joint undertaking.

Finally, the Council's actions recognize that what is needed is not leadership in space per se, but leadership in using space to address important human concerns. Space offers unlimited potential for improvement in almost every area of human endeavor; such as in medicine, where microgravity may offer new and undreamed of pharmaceuticals and cures; in industry, where productivity may be increased and made more affordable; and in national security, where space capabilities allow us to verify arms treaty provisions and counter threats to the nation's well-being. Space also offers tremendous potential for new sources of needed materials and clean, unlimited energy.

The excitement and challenge of the space program, both manned and robotic, can be a powerful motivator for young people to enter science, engineering, and technology fields. This was clearly shown during the Apollo moon program, when advanced degrees in these fields rose dramatically in response to the program's investments. The Space Council plans to continue to emphasize education as an integral part of the space program.

The President and Vice President have given America a clear vision of a bright, prosperous future. It is a vision based on the unlimited potential of space to benefit mankind; but one that

can be realized only if all Americans commit themselves to U.S. leadership of a global campaign to explore space, understand and appreciate it, and harness it in service to mankind.

Today, America is faced with tremendous, all-pervasive challenges — in medicine, in energy, in industrial competitiveness, in national security, in the environment, and elsewhere. How well we meet these challenges will determine how we and all citizens of the world live in the future. The real questions that confront us are whether we appreciate their urgency, whether we understand the potential of space in meeting them, and, understanding that potential, whether we as a nation are willing to make the major commitments necessary to engage in the exploration of space with the dedication and seriousness that these challenges demand.

Fortunately, America and the world now have new opportunities to consider and act on these challenges. The relaxation in world tensions and the resulting spirit of cooperation permeating all of Europe, extending even to the Soviet Union, offer unprecedented opportunities for realigning our nation's scientific and technical resources toward space and for achieving true cooperation among nations. Surely now is the time to capitalize on these opportunities.

It is with these thoughts in mind that the National Space Council has undertaken its efforts during the past year. While the Council recognizes the urgent need for increased commitment in space, it also appreciates the unrelenting need to put our national and international space activities on a

sound footing once and for all. Only such a foundation can effect an efficient transition from a space effort geared toward research to one that applies the potential of space to solve mankind's problems and assure our nation's future.

To begin the process of establishing that sound footing, the council implemented its charter by setting up a plan that identified four phases: setting broad goals and objectives for America in space, establishing strategies for achieving those goals and objectives, monitoring the implementation of those strategies, and resolving specific program or policy issues.

To undertake these functions we articulated America's space strategy as a set of critical elements for attaining the benefits space offers. In the preceding pages we have defined these major elements and outlined the various investigations we have conducted or are in the process of undertaking. The sole purpose of all our activities is to determine where we are and where we must go to take maximum advantage of the opportunities offered by space exploration and exploitation.



***NASA Briefing to National Space Council
on
The Advisory Committee on the Future
of the U.S. Space Program Recommendations***

Richard H. Truly
Administrator

January 11, 1991

- **Chronology**
- **NASA Action on Advisory Committee**
 - **Recommendations**
 - **Items for Consideration**
 - **Emphasized Text**

THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

CHRONOLOGY

Event	1990						1991											
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Advisory Committee Appointed by Administrator with 120 Day Charter	▲ 25																	
Vice President, Admiral Truly, and Committee Members Initial Meeting		▲ 18	ADVISORY COMMITTEE MEETINGS															
Advisory Committee Results Presented to Admiral Truly and Vice President						▲ 4												
Advisory Committee Results Presented to NSpC						▲ 10												
Advisory Committee Meeting with NASA Senior Management						▲ 15												
Committee Report Officially Released						▲ 19												
Advisory Committee Revisit on Implementation Status												△						
NSpC Meeting on Implementation						▲ 10							△ ▲					

KEY	
▲	Completed
△	Schedule for Completion
▲ ▲	Proposed

THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

NASA ACTION PLAN

			1991											
Advisory Committee Recommendation	Action	NASA Position	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1 Science First Priority Funded at Current Fraction	NASA	Concur	BUDGETED											
2 Implement Science Strategic Plan	NASA	Concur	COORDINATED WITH SCIENCE COMMUNITY AND BUDGETED											
3 Mission to Planet Earth A. Conduct as an Evolving Program B. Multi-sized Spacecraft C. NASA Re-establish Environmental Satellite R & D; NOAA Fund Production and Operation	NASA NASA/DOC	Concur (Define) Concur (Define with NOAA)												
4 Reaffirm Ultimate Goal of SEI as Human Exploration of Mars	White House	Support												
5 Configure SEI to Open-Ended Schedule	White House	—												
6 Reconfigure/Reschedule Space Station Freedom	NASA	Concur (Define)	RESTRUCTURE	PROGRAM REVISION										
7 Pursue Technology to Enable Moon Outpost/Robotic Missions	NASA	Concur (Define)	SEE RECOMMENDATION 8B											
8 Augmented Advanced Technology A. Enhance Budget B. Agency-Wide Space Technology Plan with Outside Review	NASA/OMB NASA	Under Review Concur (Define)	REQUIREMENT FOR ENHANCEMENT RECOGNIZED											

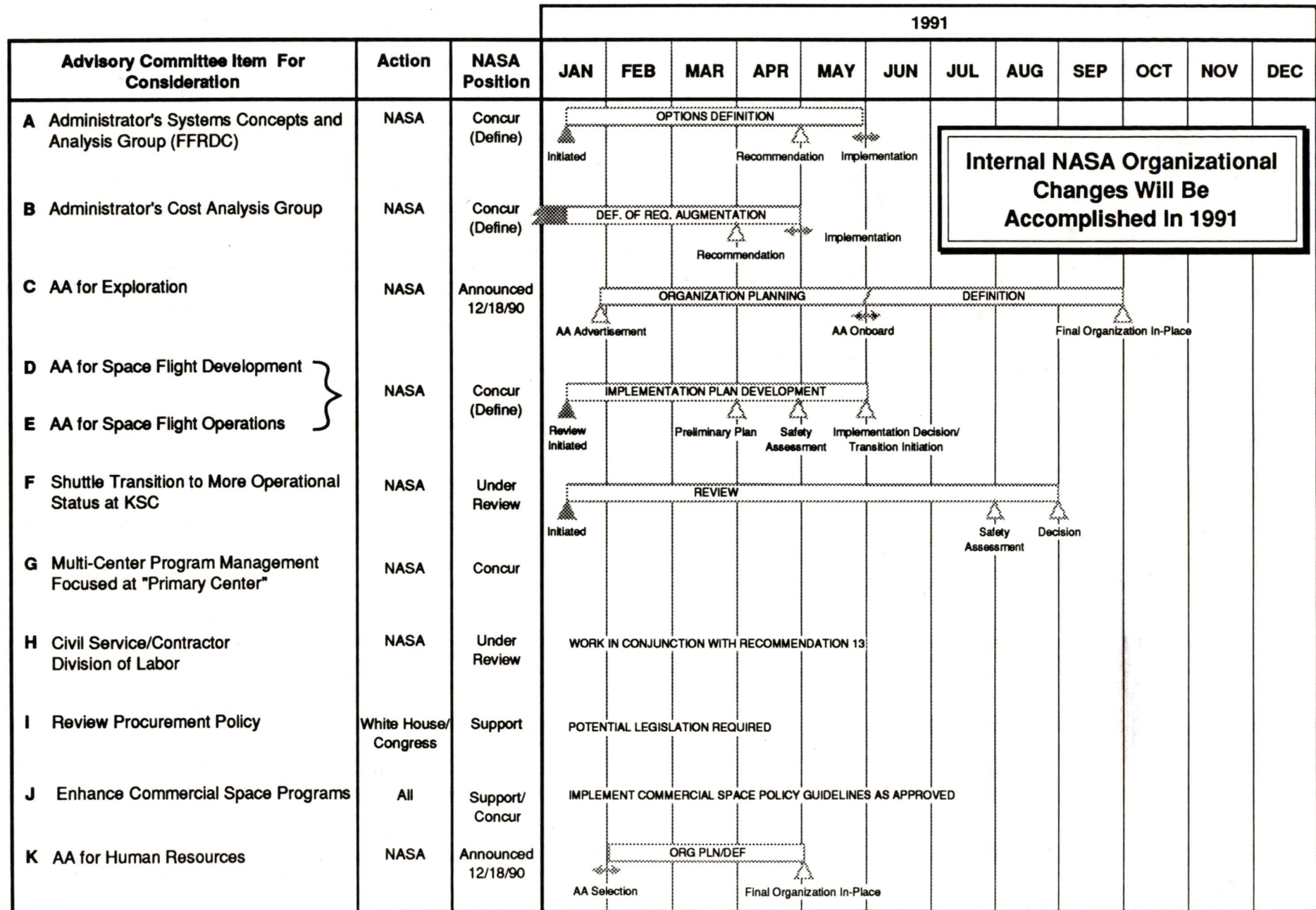
THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

NASA ACTION PLAN

Advisory Committee Recommendation	Action	NASA Position	1991											
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
9 Establish/Fund Evolutionary HLLV Program	White House	Support												
10 Orbiter Production														
A. Defer Additional Orbiter Based on New HLLV Availability	NASA	Concur FY92												
B. Continue Spares Procurement	NASA	Concur	BUDGETED											
11 Require Space Station Alternate Personnel Transportation														
A. Provide for Introduction of One-Way Crew Return	NASA	Concur												
B. Provide for Introduction of Two-Way Capability	NASA	Under Review												
12 National Space Council Executive Committee	White House	---												
13 Administrator Review of NASA Center Roles	NASA	Concur												
14 OPM Identify NASA as Pathfinding Agency for Personnel Management	OPM	Support/ Concur												
15 OPM Expand/Fully Utilize Flexible Personnel Authorities	OPM/ NASA	Support/ Concur												

THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

NASA ACTION PLAN



THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

NASA ACTION PLAN

Advisory Committee Emphasized Text	Action	NASA Position	1991											
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1 Emphasize and Provide Continuity of Research Support Activities	NASA	Concur	POLICY PREPARATION ON-GOING MANAGEMENT ACTIONS											
			▲ Policy Initiated		▲ Policy Statement									
2 Increase Use of Universities as "Prime" Contractors for Research Instruments and Projects	NASA	Under Review	WORK IN CONJUNCTION WITH RECOMMENDATION 13											
3 OSTP Review of MTPE Decision Process	White House	— —												
4 Assess Feasibility of Commercial Operator for Environment and Land Satellites	White House	— —												
5 Space Station Continue as Initial Building Block of Manned Exploration Program	NASA	Concur	ON-GOING MANAGEMENT ACTION											
6 Move NASP Forward to X-Vehicle Flight Program	White House	Support												
7 NASA Continue as Nation's Principal Agent for Civil Space	White House	Support												

NATIONAL SPACE COUNCIL

**OVERVIEW
of the
RECOMMENDATIONS
of the
ADVISORY COMMITTEE
ON THE FUTURE OF THE U.S. SPACE PROGRAM**

JANUARY 10, 1991

AUGUSTINE COMMITTEE RECOMMENDATIONS

IMPLEMENTATION CROSS-WALK

<u>Recommendation</u>	<u>NASA</u>	<u>Interagency</u>	<u>Budget</u>	<u>Legislation</u>	<u>Policy</u>	<u>Procurement</u>
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1	X					X
2	X			X		
3		X				X
4		X		X		X
5		X		X		X
6	X			X		X

(To be addressed at Space Council mtg. on January 25, 1991)

7	X	(Synthesis Group)				
8	X	(Synthesis Group)		X		
9		X		X		X
10	X			X		X
11	X			X		X
12		X				
13	X					
14		X			X	
15		X			X	

SUMMARY	8	7	 	8	2	8	0
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AUGUSTINE COMMITTEE MANAGEMENT RECOMMENDATIONS

IMPLEMENTATION CROSS-WALK

<u>Recommendation</u>	<u>NASA</u>	<u>Interagency</u>	<u>Budget</u>	<u>Legislation</u>	<u>Policy</u>	<u>Procurement</u>
A	X			X		
B	X					
C	X					
D	X					
E	X					
F	X					
G	X					
H	X					X
I		X		X		X
J		X		X	X	X
K	X					
SUMMARY	9	2	0	3	1	3

AUGUSTINE COMMITTEE "BOLD TYPE" SUGGESTIONS

IMPLEMENTATION CROSS-WALK

<u>Recommendation</u>	<u>NASA</u>	<u>Interagency</u>	<u>Budget</u>	<u>Legislation</u>	<u>Policy</u>	<u>Procurement</u>
I	X					X
II	X					X
III		X			X	
IV		X		X	X	
V	X*					
VI		X		X		
VII		X*				
SUMMARY	3	4		1	1	2
					2	2

* Declaratory statement, no action required.

AUGUSTINE COMMITTEE CROSS-WALK SUMMARY

<u>Recommendations</u>	<u>NASA</u>	<u>Interagency</u>	<u>Budget</u>	<u>Legislation</u>	<u>Policy</u>	<u>Procurement</u>
33	20	13	9	6	11	5

AUGUSTINE COMMITTEE RECOMMENDATIONS

Recommendation 1: That the civil space science program should have first priority for NASA resources, and continue to be funded at approximately the same percentage of the NASA budget as at present (about 20 percent).

Recommendation 2: That, with respect to program content, the existing strategic plan for science and applications research proposed by NASA with input from the science community be funded and executed.

Recommendation 3: That the multi-decade set of projects known as Mission to Planet Earth be conducted as a continually evolving program rather than as a mission whose design is frozen in time. A combination of different size spacecraft appears to be most appropriate to meet the needs of simultaneity, accuracy, continuity and robustness. NASA also should re-establish research and development in support of environmental satellites to meet NOAA-stated requirements. NOAA, for its part, must budget adequately to finance the operational costs of spacecraft and instruments, as well as related day-to-day support activities.

Recommendation 4: That the Mission from Planet Earth be established with the long-term goal of human exploration of Mars, underpinned by an effort to produce significant advances in space transportation and space life sciences.

Recommendation 5: That the Mission from Planet Earth be configured to an open-ended schedule, tailored to match the availability of funds.

Recommendation 6: That NASA, in concert with its International partners, reconfigure and reschedule the Space Station Freedom with only two missions in mind first, life sciences experimentation (including the accrual of operational experience on very long-duration human activities in space) and, second, microgravity research and applications. In so doing, steps should be taken to reduce the station's size and complexity, permit greater end-to-end testing prior to launch, reduce transportation requirements, reduce extra-vehicular assembly and maintenance, and, where it can be done without affecting safety, reduce cost. The planned ninety days may prove an inadequate period of time to conduct so significant a reassessment. Such time as is required should be taken.

Recommendation 7: That technology be pursued which will enable a permanent, possibly man-tended outpost to be established on the Moon for the purposes of exploration and for the development of the experience base required for the eventual human exploration of Mars. That NASA should initiate studies of robotic precursor missions and lunar outposts.

Recommendation 8: That NASA, in concert with the Office of Management and Budget and appropriate Congressional committees, establish an augmented and reasonably stable share of NASA's total budget that is allocated to advanced technology development. A two- to three-fold enhancement of the current modest budget seems not unreasonable. In addition, we recommend that an agency-wide technology plan be developed with inputs from the Associate Administrators responsible for the major development programs, and that NASA utilize an expert, outside review process, managed from headquarters, to assist in the allocation of technology funds.

Recommendation 9: That the Administration promptly establish and fund a firm program for development of an evolutionary, unmanned but man-rateable, heavy lift launch vehicle. This system should reach operational capability in time to support all but the initial phase of the Space Station deployment.

Recommendation 10: The Committee recommends that the procurement of an additional Space Shuttle orbiter, for a five-orbiter fleet operation, not be undertaken at this time, but spares procurement should continue. If an orbiter is lost in the relatively near future, the decision on whether to procure another orbiter should be made in the context of the availability of the new heavy lift launch vehicle and the demands on the remaining orbiter fleet.

Recommendation 11: That NASA initiate design effort so that manned activity in the Space Station could be supported in the absence of the Space Shuttle. Crew recovery capability must be available immediately, and provision made for the relatively rapid introduction of a two-way personnel transport module on a selected expendable launch vehicle.

Recommendation 12: That a Space Council Executive Committee, chaired by the Vice President and consisting of the Administrator of NASA, the Directors of the Office of Management and Budget and the Office of Science and Technology Policy, the Secretary of Defense and the Director of Central Intelligence, be institutionalized. Other Space Council principals should participate in the Space Ex-Comm meetings when appropriate, at the invitation of the Chairman. Major issues would continue to be addressed by the Space Council as a whole.

Recommendation (13): That NASA management review the mission of each center and consolidate and refocus centers of excellence in currently relevant fields of science and technology with minimum overlap between centers. An appropriate balance between in-house and external activity also should be developed.

Recommendation 14: That NASA should be designated a "pathfinding" agency for the implementation of an advanced personnel management system. Under this system the current legislative package would be expanded to include "pay for performance"; more flexibility in senior executive hiring, evaluation and removal; additional cost reimbursement for relocation; and a capability for handling extended temporary duty costs. NASA management should propose to OPM the personnel package it deems appropriate in the above regards.

Recommendation 15: That the Office of Personnel Management provide NASA the full flexibility permitted by law regarding dual compensation waivers, and that OMB allocate to NASA a significant portion of the 800 now approved "world-class" positions. NASA also should fully utilize the authority granted by the Space Act and fill all 425 "critical" personnel positions, thus helping redress locality pay inequities that will not be alleviated quickly enough by pay reform. New legislation should authorize NASA broad authority to establish, set the pay of, and fill up to 10 percent of its positions with "critical skills" appointments. In the event that recent and planned civil service reforms do not promptly alleviate the shortcomings of the NASA personnel system, then NASA should initiate the process of selectively phasing additional centers into the Jet Propulsion Laboratory model; that is, affiliate them with a university as Federally Funded Research and Development Centers.

AUGUSTINE COMMITTEE "BOLD TYPE" SUGGESTIONS

Suggestion I: We conclude, therefore, that Research and Analysis Programs, Mission Operations and Data Analysis Programs, and the Advanced Technology Development Programs should be viewed as equally essential to the overall research program as are hardware projects themselves; that a "fast track" procurement process be devised for such programs; and that the resources allocated to these support activities not be used as "contingency" resources for unexpected problems encountered on large flight projects.

Suggestion II: We urge that universities, other organizations and their Investigator teams be used increasingly as "prime" contractors for space research instruments and projects.

Suggestion III: The Committee believes that a review of the decision-making process for Mission to Planet Earth, including its relation to the U.S. Global Change Research Program, should be carried out for the national Space Council by a group from government, industry and academia, headed by the Director of the Office of Science and Technology Policy (OSTP). The review should consider interagency aspects, the role of the CEES, and international dimensions, and make recommendations aimed at ensuring the success and continuity of the program.

Suggestion IV: Consequently, the Committee urges that the National Space Council, together with OSTP and OMB, undertake a feasibility study to determine if a single commercial entity could provide more cost-effective management for operational environmental and land remote-sensing satellites. The prospects for an international consortium should be evaluated.

Suggestion V: Although warranting reconfiguration and probably rescheduling, the Space Station remains, in our judgment, the essential initial building block of the manned exploration program.

Suggestion VI: Even so, the relatively modest expenditures needed to move the NASP initiative briskly forward towards a technology demonstration flight program with an X-vehicle are worthwhile, given the potential for major breakthrough capability. This is exactly the kind of revolutionary program NASA should undertake, although we do not assign it high schedule urgency.

Suggestion VII: That NASA should continue to be the nation's principal agent for carrying out its civil space program, under policy guidance from the Space Council, and drawing as appropriate on other government resources and the capabilities of the private sector and academia.

AUGUSTINE COMMITTEE MANAGEMENT RECOMMENDATIONS

Item A: That a Systems Concepts and Analysis Group be formed in the NASA headquarters to serve the Administrator. This group would consist of a small elite civil service staff supplemented by a new or existing Federally Funded Research and Development Center (FFRDC).

Item B: That an independent cost analysis group be formed to serve the Administrator and the Administrator's staff. This group should be charged with the responsibility of providing to the Administrator a recommendation on all significant cost estimates provided to the Congress or to the Office of Management and Budget. Their cost estimating procedures should include contingency analysis techniques.

Item C: That an Associate Administrator for Exploration be established with responsibility for both robotic and manned exploration of the Moon and Mars, the humans-in-space portion of life-science studies, and technological foundations for manned and unmanned exploration of the Moon and Mars.

Item D: That the Space Station and other space flight development programs report to a NASA Associate Administrator for Space Flight Development.

Item E: That an Associate Administrator for Space Flight Operations be established whose responsibilities initially would include Space Shuttle operations, existing ELV operations, and tracking and data functions. Prior to implementing any such change, a detailed transition plan should be prepared and afforded full safety review and approval.

Item F: NASA should begin the deliberate process of planning for the transition of the Space Shuttle from development to a more nearly operational status at Kennedy Space Center with continuing technical support from other centers, and with appropriate certification of safety considerations at each step of the transfer process.

Item G: That NASA adopt as standard for the management of multi-center programs, a headquarters project manager and staff located at or near the "Primary Center" involved in the undertaking. A key attribute of such a project office would be its systems engineering capability.

Item H: NASA should concentrate its "hands-on" expertise in those areas unique to its mission, and avoid the excessive diversion of technical or mission specialists to functions which could be performed elsewhere. Contract monitoring is best accomplished by a cadre of professional systems managers with appropriate experience. Increased use of performance requirements, rather than design specifications, will further increase the effectiveness of this approach.

Item I: That the Legislative and Executive Branches should review the combined effect of current laws, executive orders and circulars on the efficiency of high-technology research and development operations. After review, pilot test acquisitions should be conducted with as many of the non-critical, procurement-related objectives removed as possible. The intent should be development of a more efficient process permitting both swift technical progress and sound business management. The results of the study and the pilot tests should be reported to the President and the Congress. Appropriate actions by the Legislative and executive Branches should be recommended.

Item J: Given the above, the Committee would emphasize the importance of the U.S. Government following as closely as practicable the model established by the NACS/NASA successes in the aeronautics industry in order to encourage the fullest commercial use of space. Examples wherein further government actions can be helpful include ensuring that procurements are based on "best value" rather than lowest cost; on the related experience and past performance of the contractor; on functional requirements, not on detailed design specifications; on accepting, whenever appropriate, commercial production and quality-assurance standards and techniques; and on using commercially offered space products and services whenever possible. Of particular importance is that in its commercial contracting, the government recognize the need for credible long-term contracts.

Item K: That an Associate Administrator for Human Resources be established at NASA headquarters who shall be responsible for the recruitment to ANSA of persons with critical skills, for ensuring that NASA maintain competitive compensation and personnel development policies to retain such people, and for working with OPM, OMB and the Congress on additional reforms to remove impediments to the recruitment and retention of talented and motivated people.

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January 8, 1991

U.S. COMMERCIAL SPACE POLICY GUIDELINES

A fundamental objective guiding United States space activities has been space leadership, which requires preeminence in key areas of space activity. In an increasingly competitive international environment, the U.S. Government, consistent with national security and foreign policy interests, international and domestic legal obligations, including U.S. commitments to stem missile proliferation, and agency mission requirements, encourages the commercial use and exploitation of space technologies and systems for national economic benefit.

United States space activities are conducted by three separate and distinct sectors: two U.S. Government sectors -- the civil and national security -- and a non-governmental commercial space sector. The commercial space sector includes a broad cross-section of potential providers and users, including both established and new market participants. There also has been a recent emergence of State government initiatives related to encouraging commercial space activities. The commercial space sector is comprised of at least five market areas, each encompassing both earth and space-based activities, with varying degrees of market maturity or potential:

Satellite communications - the private development, manufacture and operation of communications satellites and marketing of satellite telecommunications services, including position location and navigation;

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Materials Processing - the experimentation with and production of organic and inorganic materials and products utilizing the space environment; and

Commercial Infrastructure - the private development and provision of space-related support facilities, capabilities and services.

In addition, other market-driven commercial space sector opportunities are emerging.

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The U.S. Government encourages private investment in and broader responsibility for space-related activities that can result in products and services that meet the needs of government and other customers in a competitive market. As a matter of policy, the U.S. Government pursues its commercial space objectives without the use of direct federal subsidies. A robust commercial space sector has the potential to generate new technologies, products, markets, jobs, and other economic benefits for the nation, as well as indirect benefits for national security.

Commercial space sector activities are characterized by the provision of products and services such that:

- o private capital is at risk;
- o there are existing, or potential, non-governmental customers for the activity;
- o the commercial market ultimately determines the viability of the activity; and
- o primary responsibility and management initiative for the activity resides with the private sector.

Implementing Guidelines

The following implementing guidelines shall serve to provide the U.S. private sector with a level of stability and predictability in its dealings with agencies of the U.S. Government. The agencies will work separately but cooperatively, as appropriate, to develop specific measures to implement this strategy. U.S. Government agencies shall, consistent with national security and foreign policy interests, international and domestic legal obligations and agency mission requirements, encourage the growth of the U.S. commercial space sector in accordance with the following guidelines:

- o U.S. Government agencies shall utilize commercially available space products and services to the fullest extent feasible. This policy of encouraging U.S. Government agencies to purchase, and the private sector to sell, commercial space products and services has potentially large economic benefits.
- A space product or service is "commercially available" if it is currently offered commercially, or if it could

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be supplied commercially in response to a government procurement request.

- "Feasible" means that products and services meet mission requirements in a cost-effective manner.
- "Cost-effective" generally means that the commercial product or service costs no more than governmental development or directed procurement where such government costs include applicable government labor and overhead costs, as well as contractor charges.
- However, the acquisition of commercial space products and services shall generally be considered cost-effective if they are procured competitively using performance-based contracting techniques. Such contracting techniques give contractors the freedom and financial incentive to achieve economies-of-scale by combining their government and commercial work as well as increased productivity through innovation.
- U.S. Government agencies shall actively consider, at the earliest appropriate time, the feasibility of their using commercially available products and services in agency programs and activities.
- U.S. Government agencies shall continue to take appropriate measures to protect from disclosure any proprietary data which is shared with the U.S. Government in the acquisition of commercial space products and services.
- o U.S. Government agencies shall promote the transfer of U.S. Government-developed technology to the private sector.
 - U.S. Government-developed unclassified space technology will be transferred to the U.S. commercial space sector in as timely a manner as possible and in ways that protect its commercial value.
 - U.S. Government agencies may undertake cooperative research and development activities with the private sector, as well as state and local governments, consistent with policies and funding, in order to fulfill mission requirements in a manner which encourages the creation of commercial opportunities.
 - With respect to technologies generated in the performance of government contracts, U.S. Government agencies shall obtain only those rights necessary to

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meet government needs and mission requirements, as directed by Executive Order 12591.

- o U.S. Government agencies may make unused capacity of space assets, services and infrastructure available for commercial space sector use.
 - Private sector use of U.S. Government agency space assets, services and infrastructure and services shall be made available on a reimburseable basis consistent with OMB Circular A-25 or appropriate legislation.
- o U.S. Government agencies may make available to the private sector those assets which have been determined to be excess to the requirements of the U.S. Government in accordance with U.S. law and applicable international treaty obligations. Due regard shall be given to the economic impact such transfer may have on the commercial space sector.
- o The U.S. Government shall avoid regulating domestic space activities in a manner that precludes or deters commercial space sector activities, except to the extent necessary to meet international and domestic legal obligations, including those of the missile technology control regime. Accordingly, agencies shall identify, and propose for revision or elimination, applicable portions of U.S. laws and regulations that unnecessarily impede commercial space sector activities.
- o U.S. Government agencies shall work with the commercial space sector to promote the establishment of technical standards for commercial space products and services.
- o U.S. Government agencies shall enter into appropriate cooperative agreements to encourage and advance private sector basic research, development, and operations. Agencies may reduce initial private sector risk by agreeing to future use of privately supplied space products and services where appropriate.
 - "Anchor tenancy" is an example of such an arrangement whereby U.S. Government agencies can provide initial support to a venture by contracting for enough of the future product or service to make the venture viable in the short term. Long-term viability and growth must come primarily from the sale of the product or service to customers outside the U.S. Government.

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- There must be demonstrable U.S. Government mission or program requirements for the proposed commercial space good or service. In assessing the U.S. Government's mission or program requirements for these purposes, the procuring agency may consider consolidating all anticipated U.S. Government needs for the particular product or service, to the maximum extent feasible.
- U.S. Government agencies entering into such arrangements may take action, consistent with current policies and funding availability, to provide compensation to commercial space providers for future termination of missions for which the products or services were required.
- o The United States will work toward establishment of an international trading environment that encourages market-oriented competition by working with its trading partners to:
 - establish clear principles for international space markets that provide an atmosphere favorable to stimulating greater private investment and market development;
 - eliminate direct government subsidies and other unfair practices that undermine normal market competition among commercial firms;
 - eliminate unfair competition by governments for business in space markets consistent with domestic policies that preclude or deter U.S. Government competition with commercial space sector activities.

The U.S. Commercial Space Policy Guidelines are consistent with the National Space Policy and the U.S. Commercial Space Launch Policy which remain fully applicable to activities of the governmental space sectors and the commercial space sector.

Reporting Requirements

U.S. Government agencies affected by these guidelines are directed to report by October 1, 1991, to the National Space Council on their activities related to the implementation of these policy guidelines.

Withdrawal/Redaction Sheet

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Document No. and Type	Subject/Title of Document	Date	Restriction	Class.
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NATIONAL SPACE COUNCIL
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20500

January 8, 1991

MEMORANDUM FOR MR. J. STAPLETON ROY
Executive Secretary
Department of State

MR. WILLIAM SITTMANN
Executive Secretary
National Security Council

MR. R. BLAIR DOWNING
Executive Secretary
Department of Treasury

MR. FRANK HODSOLL
Associate Director
Office of Management
and Budget

COL JOHN A. DUBIA
Executive Secretary
Department of Defense

DR. ALLAN BROMLEY
Director
Office of Science and
Technology Policy

MR. THOMAS MURRIN
Deputy Secretary
Department of Commerce

COL ROBERT CHILCOAT
Executive Assistant
to the Chairman
Joint Chiefs of Staff

MS. RUTH KNOUSE
Director, Executive
Secretariat
Department of
Transportation

MS. JESSIE HARRIS
Executive Officer
National Aeronautics and
Space Administration

GOV. JOHN H. SUNUNU
Chief of Staff
to the President

(b)(3)

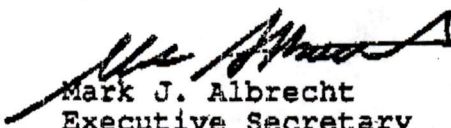
DR. FENTON CAREY
Special Assistant
to the Secretary
Department of Energy

SUBJECT: U.S. Commercial Space Policy Guidelines

Attached is policy paper, U.S. Commercial Space Policy Guidelines, which has been coordinated through the interagency process. It will be discussed at the National Space Council meeting on ~~Thursday, January 10, 1991, at 2 p.m.~~

FRIDAY 1/11 @ 11am

The meeting will be held in the Vice President's OEOB office, Room 272. Attendance will be limited to principal plus one. Please provide names of attendees to Cynthia Chase at 202-395-6175, by COB, January 8, 1991.


Mark J. Albrecht
Executive Secretary

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January 8, 1991

U.S. COMMERCIAL SPACE POLICY GUIDELINES

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Run 272

ADVANCE COPY

8

OF THE

SUMMARY AND PRINCIPAL RECOMMENDATIONS

OF THE

ADVISORY COMMITTEE ON THE FUTURE OF THE

U. S. SPACE PROGRAM

DECEMBER 10, 1990

EXECUTIVE SUMMARY

The United States' civil space program was rather hurriedly formulated some three decades ago on the heels of the successful launch of the Soviet Sputnik. A dozen humans have been placed on the moon and safely returned to earth, seven of the other eight planets have been viewed at close range, including the soft landing of two robot spacecraft on Mars, and a variety of significant astronomical and other scientific observations have been accomplished. Closer to earth, a network of communications satellites has been established, weather and ocean conditions are now monitored and reported as they occur, and the earth's surface is observed from space to study natural resources and detect sources of pollution.

Problems and Perspectives. In spite of these virtually unparalleled achievements, the civil space program and its principal agent, the National Aeronautics and Space Administration, are today the subject of considerable criticism. The source of this criticism ranges from concern over technical capability to the complexity of major space projects; from the ability to estimate and control costs to the growth of bureaucracy; and from a perceived lack of an overall space plan to an alleged institutional resistance to new ideas and change. The failure of the Challenger, the recent hydrogen leaks on several Space Shuttle orbiters, the spherical aberration problem encountered with the Hubble Space Telescope, and various launch processing errors such as a work platform left in an engine compartment and discovered during launch preparations, have all heightened this dissatisfaction.

Some of the concern is, in the view of the Committee, deserved and occasionally even self-inflicted. For example, the practice of separately reporting the cost of space missions according to accounting categories (which for bookkeeping purposes allocates launch services to a distinct account) results in confusion as to what is the actual cost of a mission.

Yet, in spite of recognized current problems, care must also be taken not to impose potentially disruptive remedies on today's NASA to correct problems that existed in an earlier NASA. The much publicized spherical aberration problem of the Hubble Space Telescope encountered this past year is in fact a consequence of an assembly error left undiscovered in tests conducted a decade ago -- in 1980. The decision to launch the Challenger

in cold weather, when the seals between rocket motor segments would be most suspect, took place five years ago and has spurred NASA to many management changes. Since the Challenger accident, NASA has increased the emphasis on safety, and has borne the burden of delaying launches when reasonable questions arose over the readiness to launch safely. On the other hand, processing incidents during launch preparation continue to occur in NASA operations, and to be the cause of justifiable concern.

Because of the intense interest in -- and scrutiny of -- America's commendably open and visible civil space program, it is sometimes easy to overlook the fact that technical problems such as hydrogen leaks, faulty seals and erroneous assembly procedures are not unique to today's space activities, or even to NASA. Although problems of any sort are most emphatically not to be condoned, when comparing today's space program with the successes of the past, it must also be recalled that America's first attempt to launch an earth satellite using the Vanguard rocket ended in failure. By the end of 1959, 37 satellite launches had been attempted: less than one-third attained orbit. Ten of the first eleven launches of unmanned probes to the moon to obtain precursor data in support of the Apollo mission failed. Three astronauts were lost in a fire aboard the Apollo capsule during ground testing. A fuel cell exploded during the mission of Apollo XIII en route to the moon, seriously damaging the spacecraft. During the few months surrounding the Challenger accident, a Delta, an Atlas-Centaur, two Titan 34-D's, a French Ariane-2 and a Soviet Proton were all lost.

Space missions, whether manned or unmanned, are fundamentally difficult and demanding undertakings that depend upon some of the world's most advanced technology. The Saturn V rocket required the integration of some six million components manufactured by thousands of separate contractors. Voyager 2 arrived at Neptune a mere one second behind its final updated schedule after a 12-year, 4.4 billion mile flight, approaching within 3,000 miles of the planet's surface. The information to be gathered by the Earth Observing System could approach 10 trillion bits of information -- about one Library of Congress -- per day. The matter of human frailty is perhaps of even greater import: in the case of the Apollo program, some 400,000 people at some 20,000 locations were involved in its design, test and operation.

Concerns. Nonetheless, given the cost of space activities, in both financial and human terms, and their profound impact on America's prestige throughout the world, no goal short of perfection is acceptable. The Committee finds that there are a number of concerns about the civil space program and NASA which are deserving of attention.

The first of these is the lack of a national consensus as to what should be the goals of the civil space program and how they should in fact be accomplished. It seems that most Americans do support a viable space program for the nation -- but no two individuals seem able to agree upon what that space program should be. Further, those immediately involved in the program often seem least inclined to compromise for the common good. Some point out that most space missions can be performed with robots for a fraction of the cost of humans, and that, therefore, the manned space program should be curtailed. Others point out that the involvement of humans is the very essence of exploration, and that only humans can fully adapt to the unexpected. Some point to the need for accelerated commercialization of space while others argue the benefits of fundamental science -- only to be challenged in turn to prove, say, the tangible value of studies in astronomy -- and so on.

Second, and closely related to this contentious yet fundamental matter, our Committee believes that NASA is currently over-committed in terms of program obligations relative to resources available -- in short, it is trying to do too much, and allowing too little margin for the unexpected. As a result, there is the frequent need to revamp major programs, which in turn sometimes results in forcing smaller (scientific) pursuits to pay the bill for problems encountered in larger (frequently manned) missions. Of major importance, in our view, is the fact that margins needed to provide confidence in maintaining cost, schedule, performance, and especially reliability, too often are minimal or absent.

Third, continuing changes in project budgets, sometimes exacerbated by actions needed to extricate projects from technical difficulties, result in management inefficiencies. These demoralize and frustrate the individuals pursuing those projects -- as well as those who must pay the bills.

Fourth, there is the matter of institutional aging and the concern that NASA has not been sufficiently responsive to valid criticism and to the need for change.

Fifth, the personnel policies embodied in the civil service system are, in the opinion of the Committee, hopelessly incompatible with the long-term maintenance of a leading-edge, aggressive, confident, and able work force of technical specialists and technically trained managers that will be needed by NASA in the years ahead.

Sixth, it is a natural tendency for projects to grow in scope, complexity, and cost. Deliberate steps must be taken to guard against this phenomenon if programs are not to collapse under their own weight -- often, as already noted, taking a toll on the smaller projects that must share in the budget.

Seventh, the material foundation of any major space project is its "technological base." It is this base that produces the key building blocks, or "enablers," that make major missions possible -- new materials, electronics, engines and the like. The technology base of NASA has now been starved for well over a decade and must be rebuilt if a sound underpinning is to be regained for future space missions.

Eighth, space projects tend to be very unforgiving of any form of neglect or human failing -- particularly with respect to engineering discipline. Spacecraft incorporating flaws are not readily "recalled" to the factory for modification. It is this category of problem that has evoked much of the criticism directed at NASA in recent years, although with new technology there are growing opportunities for systems that are "self-healing."

Finally, ninth, the civil space program is overly dependent upon the Space Shuttle for access to space. The Space Shuttle offers significant capabilities to carry out missions where humans are uniquely required -- as has been the case on a number of occasions. The Shuttle is also a complex system that has yet to demonstrate an ability to adhere to a fixed schedule. And although it is a subject that meets with reluctance to open discussion, and has therefore too often been relegated to silence, the statistical evidence indicates that we are likely to lose another Space Shuttle in the next several years ... probably before the planned Space Station is completely established on orbit. This

would seem to be the weak link of the civil space program -- unpleasant to recognize, involving all the uncertainties of statistics, and difficult to resolve.

The Space Shuttle differs in important ways from unmanned vehicles -- on the positive side it provides the flexibility and capability attendant to human presence and it permits the recovery of costly launch vehicle hardware which would otherwise be expended. On the negative side, it tends to be complex, with relatively limited margins; it has not realized the promised cost savings; and should it fail catastrophically, it takes with it a substantial portion of the nation's future manned launch capability and, potentially, several human lives.

The Committee recognizes the important role of the Space Shuttle for missions where there is the need for human involvement, and notes that the Space Shuttle is absolutely essential to America's civil space program for the next decade or more. Necessary steps to assure the viability of Space Shuttle operations this decade should therefore proceed. Nonetheless, the Committee believes in hindsight that it was, for example, inappropriate in the case of Challenger to risk the lives of seven astronauts and nearly one-fourth of NASA's launch assets to place in orbit a communications satellite.

Agency Responsibilities. Against the backdrop of these and other concerns, the Committee was asked to consider whether some altogether new form of management structure should be established to pursue portions of the nation's civil space program, as has been recommended by various observers. Such a model might include an altogether separate agency patterned after, say, the Strategic Defense Initiative Organization of the Department of Defense, which would be established to pursue major new initiatives such as the Mars exploration program. Another possibility occasionally proposed is to separate the Space Shuttle's operation from NASA so as to permit the space agency to focus upon the pursuit of advanced technology and new leading-edge missions.

The conclusion of the Committee is that changes of such sweeping scope are inappropriate. First, in spite of imperfections, by far the greatest body of space expertise in any single organization in the world resides within NASA. Further, in the case of Space Shuttle operations, the maturity of the system is neither

compatible with a (potentially disruptive) shift to a new operator nor, in the opinion of the Committee, is it ever likely to be -- even though in principle we favor private sector operations over government operations whenever practicable. NASA and its predecessor, NACA, have followed this practice with regard to the aeronautics program -- producing unmatched technology that helped make America's commercial aircraft industry preeminent in the world. A similar effort is needed with respect to space activities -- but the Space Shuttle is not, in our opinion, the correct mechanism for accomplishing this objective.

Briefly stated, the Committee believes that NASA, and only NASA, realistically possesses the essential critical mass of knowledge and expertise upon which the nation's civil space program can be sustained -- and that the task at hand is therefore for NASA to focus on making the self-improvements that gird this responsibility.

A Space Agenda. The question then arises: "What should be the U.S. space program?" Although it may be tempting to lay out an accelerated plan to accomplish the unaccomplished and to attack the unknown, to do so in the absence of fiscal and technical realism would be a disservice, and would only magnify the problem of management "turbulence" that already has been so costly to the space effort -- both in money and morale.

The question thus becomes one of what can and should the U.S. afford for its civil space endeavors in a time of unarguably great demands right here on earth, ranging from reducing the deficit to curing disease and from improving education to eliminating poverty. The answer to this question is made all the more difficult because the space program touches so many aspects of our lives and contributes to the accomplishment of goals ranging from improving education to enhancing our standard of living and from assuring national security to strengthening communications among the peoples of the world. The space program produces technology that enhances competitiveness; the largest rise and subsequent decline in the nation's output of much-needed science and engineering talent in recent decades coincided with, and some say may have been motivated by, the build-up and subsequent phase-down in the civil space program.

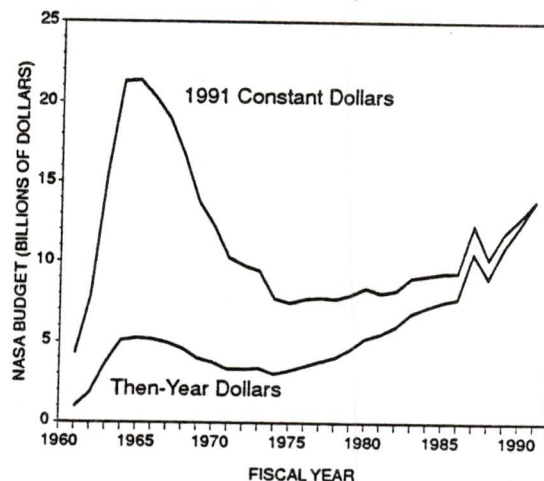
Global understanding has been enhanced through the establishment of widespread satellite telecommunications. Countless lives and considerable property have been saved through advanced weather forecasting and the use of spaceborne search and rescue systems. Basic scientific knowledge has been obtained that addresses such important questions as why one planet evolves to become altogether uninhabitable, while another nurtures life.

It can be argued that at least some of these benefits can be reaped by other more direct means. If the objective is to stimulate education, then why not give the money being spent on space to our schools? If the objective is to study the stars, then why not build more and better telescopes here on earth? To ease poverty, give aid to those in need. Yet perhaps the most important space benefit of all is intangible -- the uplifting of spirits and human pride in response to truly great accomplishments -- whether they be the sight of a single human orbiting freely around the earth at 18,000 miles per hour, or a picture of Uranus' moon Miranda transmitted 1.7 million miles through space, and taking some 2-1/2 hours merely to arrive at our listening stations even when traveling literally at the speed of light. Such accomplishments have served to unite our nation, hold our attention, and inspire us all, particularly our youth, as few other events have done in the history of our nation or even the world.

Our Committee concludes that America does want an energetic, affordable and successful space program, a predilection to which we as individuals unabashedly confess. This support has been evidenced in the gradual growth in space funding for nearly two decades (Figure 1). The question remains, however, "What should we afford?" In this regard, a historical perspective is helpful. At its peak, during the Apollo years, America spent 0.8 percent of its gross national product on its civil space program (Figure 2). This level amounted to about 4.5 percent of federal spending at the time (Figure 3) and, perhaps more importantly, about 6 percent of the discretionary portion of the federal budget (Figure 4). Today, we as a nation are spending about one-third of the Apollo peak spending as a portion of the GNP ... and the fraction of the increasingly pressured total discretionary budget has declined to 2.5 percent.

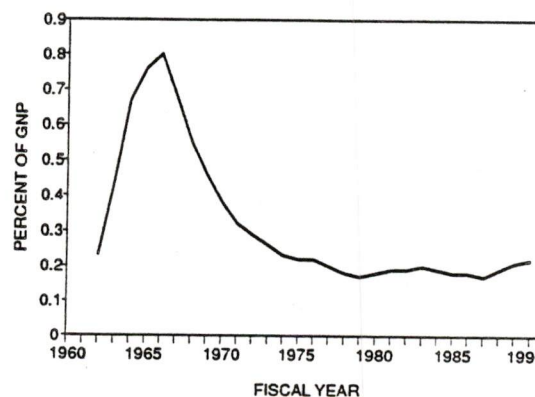
Presumably reflecting public support, both the Executive Branch and the Congress have recently shown a willingness to increase civil

FIGURE 1.
NASA Budget Trend
(Dollars)



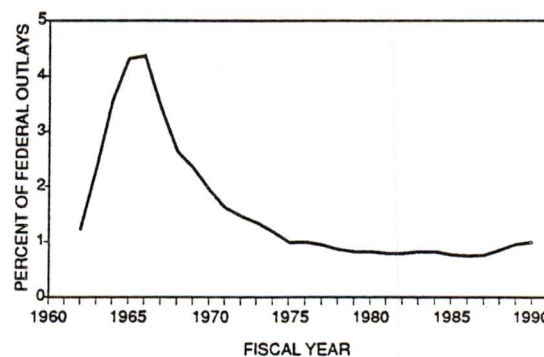
Source: NASA

FIGURE 2.
NASA Budget Trend
(Percent of GNP)



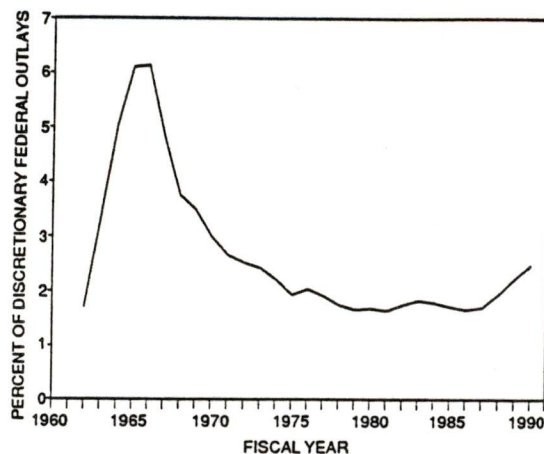
Source: Congressional Budget Office - GNP
NASA - NASA Budget

FIGURE 3.
NASA Budget Trend
(Percent of Federal Spending)



Source: NASA

FIGURE 4.
NASA Budget Trend
 (Percent of Total Discretionary
 Federal Spending)



Source: Congressional Budget Office -
 Total Discretionary Federal Spending
 NASA - NASA Budget

space spending on the order of 10 percent per year (real growth) for a well-executed program. This, therefore, is the baseline selected by this Committee to assure at least a first order fiscal test in our proposals. A larger budget would obviously permit a more energetic space program -- while the converse also is true. We recommend an approach which can accommodate, within limits, either contingency. Our specific assumption is that the civil space budget will grow by approximately 10 percent per year in real dollars throughout most of this decade, leveling out at about 0.4 percent of the GNP. This is a budget that can enable a strong space program -- but only if funding is predictable and programs are carefully managed and consistently executed. As a reference, civil space spending recently approved for 1991 represented 8.5 percent real growth over the prior year's spending.

In defining a space agenda we believe it is not sufficient merely to list a collection of projects to be undertaken in space, no matter how meritorious each may be. It is essential to provide a logical basis for the structure of the program, including a sense of priorities.

A Balanced Space Program. It is our belief that the space science program warrants highest priority for funding. It, in our judgment, ranks above space stations, aerospace planes, manned missions to the planets, and many other major pursuits which often receive greater

visibility. It is this endeavor in science that enables basic discovery and understanding, that uncovers the fundamental knowledge of our own planet to improve the quality of life for all people on earth, and that stimulates the education of the scientists needed for the future. Science gives vision, imagination, and direction to the space program, and as such should be vigorously protected and permitted to grow, holding at or somewhat above its present fraction of NASA's budget even as the overall space budget grows.

Having thus established the science activity as the fulcrum of the entire civil space effort, we would then recommend the "mission-oriented" portion of the program be designed to support two major undertakings: a Mission to Planet Earth and a Mission from Planet Earth. Both, we believe, are of considerable importance. The Mission to Planet Earth, as we would define it, is the undertaking that in fact brings space down to earth --- addressing critical, everyday problems which affect all the earth's peoples. While we emphasize the need for a balanced space program, it is the Mission to Planet Earth which connotes some degree of urgency. Mission to Planet Earth, as we would define it, comprises a series of earth-observing satellites, probes and related instruments, and a complementary data handling system aimed at producing a much clearer understanding of global climate change and the impact of human activities on earth's biosphere. This effort will provide us with a much better understanding of our environment, how we may be affecting it, and what might be done to restore it.

The Mission from Planet Earth is principally, but not exclusively, focused upon the exploration of space. This is where most of the manned space undertakings are to be pursued and as such this tends to be the most costly aspect of the civil space program.

Today, America's manned space program is at a crossroads. The Committee believes that a focus must be given to this program now if it is not merely to drift through the decade ahead. Although there is no particular timetable that can in good conscience be assigned to this pursuit, it nonetheless sorely needs agreement as to direction.

At least in part because of its cost, the manned space program has been at the very hub of controversy swirling around the nation's civil space activity. It can be argued that much

of what humans can perform in space could be conducted at less cost and risk with robotic spacecraft -- and in many instances we believe it should be.

But are there not activities in space which properly should be the province of human intelligence, flexibility and being? The Committee found it instructive in this regard to ask whether we would be content with a space program that involved no human flight. Our answer is a resounding "no." There is a difference between Hillary reaching the top of Everest and merely using a rocket to loft an instrument package to the summit. There is a difference between the now largely forgotten Soviet robotic moon explorer that itself returned lunar samples, and the exploits of astronauts Neil Armstrong, Buzz Aldrin, and Mike Collins. The Committee thus wholeheartedly endorses a far-reaching, but we believe realistic, undertaking in manned space activity, carefully paced to the availability of funds.

But if there is to be a manned space undertaking, what should it be? Surely the goal is not merely to provide routine transportation of cargo to and from space. In this regard, we share the view of the President that the long-term magnet for the manned space program is the planet Mars -- the human exploration of Mars, to be specific. It needs to be stated straightforwardly that such an undertaking probably must be justified largely on the basis of intangibles -- the desire to explore, to learn about one's surroundings, to challenge the unknown and to find what is to be found. Surely such an endeavor must be preceded by further unmanned visits, and by taking certain important steps along the way, including returning for extended periods to the moon in order to refine our hardware and procedures and to develop the skills and technologies required for long-term planetary living.

The Committee offers what we believe to be a potentially significant new approach in the planning of human space exploration. Although we appreciate the arguments for setting a "date certain" for many or even most of our space goals, as did President Kennedy with respect to going to the moon, we believe that a program with the ultimate, long-term objective of human exploration of Mars should be tailored to respond to the availability of funding, rather than to adhering to a rigid schedule. This does not demean the importance of the manned space program, but rather is a consequence of the fact

that we simply cannot know with any exactness the cost or obstacles which may impede a Mars mission. We do know that, whatever the cost is, it can be spread over many years, and that it will have to endure the changing emphasis of a series of Presidents and Congresses as well as of economic circumstances. We also believe that this is a challenge that could be constructively shared among a number of nations. The challenge, from a management standpoint, is to tailor a program, the first step of which is to generate needed technology building-blocks, which can adapt to the availability of funds. The availability of funding would then determine mission schedule -- because the converse is neither economically nor politically practical. Unforeseen fiscal demands would be borne by the program itself rather than off-loaded to other important but smaller (science) programs.

Using this management approach, the Committee believes that a sound, long-term human exploration program can be pursued. It provides an important companion to Mission to Planet Earth and clearly states America's intention to stay in space with humans.

But fundamental uncertainties remain with respect to the feasibility of long duration human spaceflight, uncertainties that revolve around the effects of solar flares, muscle deterioration due to weightlessness, the loss of calcium in human bone structure, and the impact of galactic cosmic radiation. These basic issues need to be resolved before undertaking vast projects -- by means of long-duration operations involving humans in space. We thus arrive at what we believe is the fundamental reason for building a space station: to gain the much needed life sciences information and experience in long duration space operations. Such information is vital if America is not to abdicate its role in manned spaceflight.

We do not believe that the Space Station Freedom, as we now know it, can be justified solely on the basis of the (non-biological) science it can perform, much of which can be conducted on earth or by robotic spacecraft for less cost. Similarly, we doubt that the Space Station will be essential as a transportation node -- certainly not for many years. However, the Space Station is deemed essential as a life sciences laboratory, for there is simply no earth-bound substitute. The Space Station is a critical next step if the U.S. is to have a manned space program in the future. At the same time, the

Space Station can also provide a capability for important microgravity research, and for practical experience in manufacturing under low-gravity conditions. While not, in our opinion, a sufficient justification of Space Station in and of itself, microgravity research does represent an altogether valid element of America's economic competitiveness program.

Given these conclusions, we believe the justifying objectives of the Space Station Freedom should be reduced to two: primarily life sciences, and secondarily microgravity experimentation. In turn, we believe the Space Station Freedom can be simplified, reduced in cost, and constructed on a more evolutionary, modular basis that enables end-to-end testing of most systems prior to launch, and reduces extravehicular flight requirements along the lines NASA is now considering. We also believe that steps must be taken to mitigate dependence on the Space Shuttle.

Given all of this, we would encourage NASA and the Congress not to be bound by the 90-day restructuring period for Space Station Freedom recently directed by Congress. Redesign is simply too important to take less than whatever time may be needed for a thorough reassessment and the establishment of a configuration that can earn stable, long-term funding support.

Having thus defined a Mission to Planet Earth (MTPE) and a Mission from Planet Earth (MFPE) as the keystones we recommend for America's future civil space program, there remain two vital elements of space infrastructure to which attention must be devoted. This infrastructure underpins the nation's ability to actually undertake advanced space missions, and is addressed in two parts: first, the technology base, and second, the earth-to-space transportation system. Great space pursuits should not be undertaken without proper attention being devoted to these more mundane but critical aspects of the space endeavor.

First and foremost in this foundation-laying effort is the technology base which absolutely must be replenished. America has not initiated development of a new main rocket engine -- the muscle of any space pursuit -- in nearly two decades. Work on advanced space power systems has been modest; on very high specific impulse propulsion devices even more limited, on advanced concepts such as aerobraking only

formative. In fact, the overall technical base underpinning the space program has been permitted to languish in terms of funding for several decades. This effort has not, in recent years, enjoyed the support of the Legislative Branch, or, in earlier years, of the Executive Branch. This must be corrected.

The second element of space infrastructure concerns the provision of high-confidence, reasonable-risk transportation to space. In this regard, the U.S. will be unalterably committed to the Space Shuttle for many years hence. Thus, NASA simply must take those steps needed to enhance the Shuttle's reliability, minimize wear and tear, and enhance launch schedule predictability. Cost reductions also are desirable but secondary to the preceding objectives.

We further conclude that NASA should proceed immediately to phase some of the burden being carried by the Space Shuttle to a new unmanned (but potentially man-rateable) launch vehicle that offers increased payload capacity and is derivable wherever practicable from existing components to save time and cost. Presumably, some of these components could be obtained selectively from the Shuttle system itself, including launch facilities. Future enhancements would use elements derived from the Advanced Launch System technology program in progress under the cooperative management of NASA and the Department of Defense. Such an evolving heavy-lift launch system should be designed to produce substantial reductions in launch costs; a major, albeit moderately declining, portion of NASA's budget.

It should be recognized that the substantial near-term costs of developing any new heavy-lift launch vehicle make a purely financial argument for its existence not particularly compelling. Rather, the objective is to attain a reliable, unmanned vehicle that complements the Space Shuttle and that can be used for routine space trucking, saving the Space Shuttle for those missions requiring human presence. The resulting reduced demand for the Shuttle will help relieve the schedule pressures which have contributed to some of the problems the program has encountered.

Even though selected Space Shuttle components and existing launch facilities might be used for the proposed new launch vehicle, the hazards of coupling failure modes between these two vehicles can be reduced to what we

believe is an acceptable level. In short, we must buttress the civil space program's capacity and means of access to space as soon as possible.

Over the longer term, the nation must turn to new and revolutionary technologies to build more capable and significantly less costly means to launch manned and unmanned spacecraft, including those that one day will travel to the moon and Mars. However, the type of launch vehicle and the specific operational concept that will be needed to propel spacecraft from the earth's surface to orbit and on to the moon and Mars will depend on the results of mission architecture studies now underway. In the meantime, while we await the definition of the future spacecraft and launch vehicle requirements, the nation must maintain a vigorous Advanced Launch System technology program. This program, augmented by new propulsion technologies, will provide the elements to enhance our current and evolving launch vehicle fleet and eventually provide the basis for completely new and revolutionary launch systems.

International Pursuits. NASA's accomplishments over the years in space science and technology have helped motivate other nations to pursue space programs of their own. The success and interests of these new participants in the civil space arena places NASA's role in a somewhat changed context as we approach a new millennium, one where our nation must both cooperate and compete. International cooperation can serve to demonstrate leadership, to forge productive relationships and to broaden the range of available opportunities for accomplishment, as has been shown through a long and successful history of NASA-supported international partnerships. But international agreements can also lead to bureaucratic constraints and delays where many levels of approval are required for each decision. The Committee notes that international commitments must be made carefully, supported by all affected parts of the government prior to consummation, including the Congress, and thereafter honored scrupulously. We emphasize that international cooperation should continue to be an integral part of the U.S. civil space program. But we also emphasize that the U.S. should retain management control for critical in-line program elements in certain long-term undertakings such as human space exploration, and that the U.S. must continue to have a fully competitive stance in areas such as the access to space itself, i.e., launch vehicles which have

broad impact on the fundamental viability of America's civil and commercial space programs.

Some Final Observations. This, then, is the space program that our Committee recommends. A number of further recommendations are offered in the text concerning management improvements, and the all-important matter during the years ahead of attracting to and retaining within NASA a share of the nation's most capable people. Organization charts and improved management practices will prove altogether hollow if NASA is not permitted to attract the extraordinary people needed to successfully pursue the energetic goals prescribed herein.

Many of the recommendations we offer deal with the seemingly mundane aspects of the space program -- but, in our view, are of no less importance than the higher-impact recommendations we also offer. These recommendations and suggestions are included in the text and address such matters as enhancing cost estimating capabilities, increasing cost, schedule and performance margins, and strengthening systems engineering.

How shall we pay the bills for all of this? First, as already noted, we assume growth in civil space funding for the next decade. We also recommend a redesign of the Space Station, in part, to reduce cost. We would propose diverting funds from the planned additional Space Shuttle orbiter (but not from support hardware needed to assure the Space Shuttle's continued operational viability) to enable construction of the new unmanned heavy-lift launch vehicle. We believe that a new unmanned launch vehicle itself can produce substantial savings .. but not in the near term and in the longer term only if we change our processing philosophy and manpower. We recommend configuring the long-term manned exploration program, which focuses on Mars but has critical stepping stones along the way in the form of the Space Station and a lunar base, to a schedule that adapts to the availability of funding. And we propose a number of management enhancements that should produce efficiencies and modest attendant cost savings. The most important of this category of improvement, however, is not fully within NASA's wherewithal to implement -- namely, the provision of predictable and stable funding. This will require the support of other parts of the Administration and the Congress. The essential role of this support cannot be overemphasized if

the U.S. is to have a successful civil space program.

It should also be noted that NASA has a number of other responsibilities to which it must attend. Foremost among these is the continued support of a strong aeronautics program -- the linchpin of America's competitiveness in civil aviation. NASA should also continue to help nurture a commercial space industry, as it has in recent years. The Committee is strongly committed to the free enterprise system and believes NASA should do only those things that cannot be satisfactorily performed in the private sector, including academia and industry. There are, of course, many matters which can only be done within the government, including, to name but a few, the pursuit of leading-edge, high cost research with uncertain or long-term payoff; planning and providing specialized joint-use facilities; and administering contracts and monitoring the performance of contractors.

Finally, in regard to NASA's other responsibilities, we applaud its on-going efforts to enhance the nation's mathematics and science programs.

We believe that the legacy our generation should leave to the future is that we pioneered the exploration of space, and thereby made important discoveries that will prove of benefit to all mankind. However, space activity is inherently difficult -- involving advanced technology and taking place over great distances. It demands reliance upon machines, often very complex machines, which are designed, tested and operated by mortals. It involves rewards which may be intangible.

As we labor under such challenges, we should insist upon excellence. We should strive for perfection. We should demand the utmost of those to whom we entrust our space endeavor. But we should be prepared for the occasional failure. If we as a nation are to place a greater premium on letting nothing go wrong, on not making errors, and on ridiculing those who strive but occasionally fail, than we place upon seeking potentially great accomplishments, then we have no business in space.

PRINCIPAL RECOMMENDATIONS

This report offers specific recommendations pertaining to civil space goals and program content as well as suggestions relating to internal NASA management. These are summarized below in four primary groupings. In order to implement fully these recommendations and suggestions, the support of both the Executive Branch and Legislative Branch will be needed, and of NASA itself.

Principal Recommendations Concerning Space Goals

It is recommended that the United States' future civil space program consist of a balanced set of five principal elements:

- a science program, which enjoys highest priority within the civil space program, and is maintained at or above the current fraction of the NASA budget
- a Mission to Planet Earth (MTPE) focusing on environmental measurements
- a Mission from Planet Earth (MFPE), with the long-term goal of human exploration of Mars, preceded by a modified Space Station which emphasizes life-sciences, an exploration base on the moon, and robotic precursors to Mars
- a significantly expanded technology development activity, closely coupled to space mission objectives, with particular attention devoted to engines
- a robust space transportation system

Principal Recommendations Concerning Programs

With regard to program content, it is recommended that:

- the strategic plan for science currently under consideration be implemented
- a revitalized technology plan be prepared with strong input from the mission offices, and that it be funded

- Space Shuttle missions be phased over to a new unmanned (heavy-lift) launch vehicle except for missions where human involvement is essential or other critical national needs dictate
- Space Station Freedom be revamped to emphasize life-sciences and human space operations, and include microgravity research as appropriate. It should be reconfigured to reduce cost and complexity; and the current 90-day time limit on redesign should be extended if a thorough reassessment is not possible in that period.
- a personnel module be provided, as planned, for emergency return from Space Station Freedom, and that initial provisions be made for two-way missions in the event of unavailability of the Space Shuttle

Principal Recommendations Concerning Affordability

It is recommended that the NASA program be structured in scope so as not to exceed a funding profile containing approximately 10 percent real growth per year throughout the remainder of the decade and then remaining at that level, including but not limited to the following actions:

- redesign and reschedule the Space Station Freedom to reduce cost and complexity
- defer or eliminate the planned purchase of another orbiter
- place the Mission from Planet Earth on a "go-as-you-pay" basis, i.e., tailoring the schedule to match the availability of funds

Principal Recommendations Concerning Management

With regard to management of the civil space program, it is recommended that:

- an Executive Committee of the Space Council be established which includes the Administrator of NASA
- major reforms be made in the civil service regulations as they apply to specialty skills; or, if that is not possible, exemptions be granted to NASA for at least 10 percent of its

employees to operate under a tailored personnel system; or, as a final alternative, that NASA begin selectively converting at least some of its centers into university-affiliated Federally Funded Research and Development Centers

- NASA management review the mission of each center to consolidate and refocus centers of excellence in currently relevant fields with minimum overlap among centers

It is considered by the Committee that the internal organization of any institution should be the province of, and at the discretion of, those bearing ultimate responsibility for the performance of that institution. Hence, the following possible internal structural changes are offered for the consideration of the NASA Administrator:

- That the current headquarters structure be revamped, disestablishing the positions of certain existing Associate Administrators in order that:

- an Associate Administrator for Human Resources be established, whose responsibilities include making NASA a "pathfinding" agency in acquisition and retention of the highest quality personnel for the federal government.
- an Associate Administrator for Exploration be established, whose responsibilities include robotic and manned exploration of the moon and Mars.
- an Associate Administrator for Space Flight Operations be established, whose responsibilities include Space Shuttle operations, existing expendable launch vehicle operations, and tracking and data functions.
- an Associate Administrator for Space Flight Development be established, whose responsibilities include Space Station Freedom and other development projects such as the Advanced Solid Rocket Motor and the new Heavy Lift Launch Vehicle.

- an exceptionally well-qualified independent cost analysis group be attached to headquarters with ultimate responsibility for all top-level cost estimating including cost estimates provided outside of NASA.
- a systems concept and analysis group reporting to the Administrator of NASA be established as a Federally Funded Research and Development Center.
- multi-center projects be avoided wherever possible, but when this is not practical, a strong and independent project office reporting to headquarters be established near the center having the principal share of the work for that project; and that this project office have a systems engineering staff and full budget authority (ideally industrial funding - - i.e., funding allocations related specifically to end-goals).

In summary, we recommend:

- 1) Shifting the priorities of the space program to place primary emphasis on science.
- 2) Obtaining exclusions for a portion of NASA's employees from existing civil service rules or, failing that, beginning a gradual conversion of selected centers to Federally Funded Research and Development Centers affiliated with universities, using as a model the Jet Propulsion Laboratory.
- 3) Redesigning the Space Station Freedom to lessen complexity and reduce cost, taking whatever time may be required to do this thoroughly and innovatively.
- 4) Pursuing a Mission from Planet Earth as a complement to the Mission to Planet Earth, with the former having Mars as its very long-term goal -- but relieved of schedule pressures and progressing according to the availability of funding.
- 5) Reducing our dependence on the Space Shuttle by phasing over to a new unmanned heavy-lift launch vehicle for all but missions requiring human presence.

* * *

The Committee would be pleased to meet again in perhaps six months should the NASA Administrator so desire, in order to assist in the implementation process. In the meantime, NASA may wish to seek the assistance of its regular outside advisory group, the NASA Advisory Council, to provide independent and ongoing advice for implementing these findings.

Each of the recommendations herein is supported unanimously by the members of the Advisory Committee on the Future of the U.S. Space Program (see Appendix III).

APPENDICES

- I. BIOGRAPHIES OF MEMBERS**
- II. TERMS OF REFERENCE**
- III. LEGAL COMPLIANCE**
- IV. LIST OF WITNESSES**
- V. BIBLIOGRAPHY**

Appendix I

BIOGRAPHIES OF MEMBERS

Chairman:

Norman R. Augustine Mr. Augustine is Chairman and CEO of the Martin Marietta Corporation. He has previously served as the Under Secretary of the Army, Assistant Secretary of the Army for Research and Development and as an Assistant Director of Defense Research and Engineering in the Office of the Secretary of Defense. He is an Honorary Fellow and former President of the American Institute of Aeronautics and Astronautics and is a Fellow of the Institute for Electrical and Electronic Engineers. He has served as Chairman of the Defense Science Board and of the Aeronautics Panel of the Air Force Scientific Advisory Board. He is the author of several books including one on the management of large technical projects and is a member of the National Academy of Engineering. He currently serves as Vice President of the Boy Scouts of America. Mr. Augustine holds Bachelors and Masters degrees in aeronautical engineering from Princeton University and has three honorary doctorate degrees.

Vice-Chairman:

Laurel L. Wilkening Dr. Wilkening is the Provost and Vice President for Academic Affairs of the University of Washington, where she is also Professor of Geological Sciences and Adjunct Professor of Astronomy. Prior to going to the University of Washington, she was Vice President for Research and Dean of the Graduate College and Professor of Planetary Sciences at the University of Arizona. She also served as Director of the Lunar and Planetary Laboratory there from 1981-1983. As a planetary scientist, her areas of research are meteorites, asteroids, and comets. The book Comets, which she edited in 1982, is a widely used reference on the topic. In 1985, President Reagan appointed her Vice Chairman of the National Commission on Space. Dr. Wilkening earned a Ph.D. in chemistry from the University of California, San Diego in 1970, and a B.A. in chemistry from Reed College, Portland, Oregon in 1966.

Members:

Edward C. (Pete) Aldridge, Jr. Mr. Aldridge is currently President, McDonnell Douglas Electronic Systems Company, in McLean, Virginia. Prior to this position, Mr. Aldridge was Secretary of the Air Force from 1986-1988. He joined the Reagan Administration in 1981 as the Under Secretary of the Air Force, in which one of his key responsibilities was coordinating the Air Force and national security space activities. Mr. Aldridge was in astronaut training before the Challenger accident. He has held numerous management positions in government (Office of the Secretary of Defense, Office of Management and Budget) and the aerospace industry (System Planning Corporation, LTV Corp and Douglas Aircraft Co.). Mr. Aldridge was an advisor on the Strategic Arms Limitation Talks (SALT I) in 1970-72. He holds a B.S. in Aeronautical Engineering from Texas A&M University and an M.S. in aeronautical engineering from the Georgia Institute of Technology.

Joseph P. Allen Dr. Allen is currently President, Space Industries International, in Houston, Texas. From 1967 until his employment with the company, Dr. Allen served as an astronaut with NASA. His management duties involved astronaut candidate selection and training and he additionally served as a ground support crewman and CAPCOM for Apollo 15, Apollo 17 and STS-1. He flew as a prime crew member on STS-5, the first Shuttle flight to deploy cargo in space, and on STS 51-A, the first space flight to salvage equipment from space. Dr. Allen also served at NASA Headquarters as Assistant Administrator for Legislative Affairs from 1975-1978. He is the author of Entering Space, a personal account of the space flight experience, and has published widely in the fields of science education and nuclear physics.

research. Dr. Allen received an undergraduate degree in mathematics and physics from DePauw University and holds Masters and Doctorate degrees in physics from Yale University.

D. James Baker Dr. Baker is President of Joint Oceanographic Institutions Incorporated in Washington, D.C., and Distinguished Visiting Scientist at the Jet Propulsion Laboratory. He is author of Planet Earth - The View from Space (Harvard University, 1990). He is a member of the National Research Council Committee on Global Change and the Ocean Studies Board, and is an officer of the international Joint Scientific Committee for the World Climate Research Programme. He has served as chairman of the NRC Panel to Review the Earth Observing System and chairman of the NASA Center Science Assessment Team. He has served as a member of the NRC Space Studies Board, the NASA Space and Earth Science Advisory Committee, and the Department of Commerce Committee on Commercialization of Landsat. He is President of the Oceanography Society and a Fellow of the American Association for the Advancement of Science. Dr. Baker has published more than 80 papers on oceanography and space and held positions at the University of Washington and Harvard University. He has a B.S. in physics from Stanford University and a Ph.D. in physics from Cornell University.

Edward P. Boland Congressman Boland was elected to the U. S. House of Representatives in 1953 and served continuously through the end of the 100th Congress in 1988. In 1955 he joined the Committee on Appropriations and was a member of the Independent Offices (now the VA, HUD, and Independent Agencies) Subcommittee. In 1971, he became Chairman of this subcommittee and dealt with several scientific agencies including the National Aeronautics and Space Administration (formerly the National Advisory Committee on Aeronautics), the National Science Foundation, and the Office of Science and Technology Policy. He also served as Chairman of the first House Permanent Select Committee on Intelligence overseeing the budgets of the Central Intelligence Agency, and other intelligence-related agencies. In 1983, Congressman Boland received the Olin E. Teague Space Award in recognition of his outstanding guidance and dynamic leadership in space science. In 1986, he received the National Science Foundation Distinguished Public Service Award presented in recognition of his contribution to the progress of science, engineering, and mathematics. He attended Boston College Law School.

Daniel J. Fink Mr. Fink is President of D. J. Fink Associates, Inc. which provides management consulting to technology-based industries. His over 40 years in aerospace engineering and management include service in the DOD as Deputy Director, Strategic & Space Systems. Following his government service he joined the General Electric Co. in 1968. He was Vice President of that company where he first led GE's Space Division, then its Aerospace Group, and later was Senior Vice President Corporate Development and Planning. Mr. Fink serves on the Defense Science Board and is a former Chairman of the NASA Advisory Council. He is a Member of the National Academy of Engineering and was Chairman of the NRC Space Applications board and its Board on Telecommunications and Computer Applications. His honors and awards include the DOD Distinguished Service Award, the NASA Distinguished Public Service Medal and the Collier Trophy (for his work on Landsat). He is an Honorary Fellow of the American Institute of Aeronautics & Astronautics and a former President. He received his B.S. and M.S. in aeronautical engineering from M.I.T.

Don Fuqua Mr. Fuqua is President and General Manager of the Aerospace Industries Association and serves as leading spokesperson for the U.S. aerospace industry. Before joining AIA, Mr. Fuqua served 12 terms as a U.S. Congressman, representing Florida's Second Congressional District. He was elected Chairman of the House Science and Technology Committee in 1979 after serving on the Committee since joining Congress in 1963. He is a member of the National Aeronautics and Space Administration's Advisory Council and is a founding member of the Challenger Center for Space Science Education. Mr. Fuqua has received numerous awards including the Rotary National Award for Space Achievement in 1988, and the National Aeronautics and Space Administration Distinguished Public Service Medal and the National Science Foundation Distinguished Public Service Award, both in 1986. Mr. Fuqua graduated from the University of Florida with a degree in agriculture economics. He also has honorary doctorate

degrees from the University of Notre Dame, Florida Institute of Technology, Florida State University, and Florida A&M University.

Robert T. Herres General Herres retired in March 1990 after 36 years of military service to become President of P&C at USAA, an insurance and financial services provider. The last three years of his military career were spent as Vice Chairman of the Joint Chiefs of Staff. Space-related assignments included service as Commander-in-Chief of U.S. Space Command, North American Aerospace Defense Command, and Commander of the Air Force Space Command. He was also Director of Command, Control and Communications Systems on the Joint Staff, Commanded the Eighth Air Force and the Air Force Communications Command. Earlier, General Herres was the Air Force Flight Test Center's Chief of Plans and Requirements and Chief of the Flight Crew Division for the Manned Orbiting Laboratory Program subsequent to completing the Air Force's Test Pilot School. He is a Naval Academy graduate and holds Masters' Degrees in electrical engineering and public administration.

David T. Kearns Mr. Kearns is Chairman of Xerox Corporation, Stamford, Connecticut. Mr. Kearns joined Xerox in July 1971 as a corporate vice president. In 1972, he became President of the Company's copier/duplicator group. He was named Executive Vice President, International Operations in 1976. He was named President and Chief Operating Officer in 1977 and Chief Executive Officer in 1982. Mr. Kearns served as Chief Executive Officer until he relinquished that position in August 1990. Prior to joining Xerox, Kearns was a Vice President of the data processing division of International Business Machines Corporation. Mr. Kearns is a member of the President's Education Policy Advisory Committee, the Business Council, the Council on Foreign Relations, the Trilateral Commission and the American Philosophical Society. He is a member of the Board of Directors of Chase Manhattan Corporation, Time Warner Incorporated, Ryder System, Inc., and the Dayton Hudson Corporation. He also serves as a member of the Board of Trustees of the Ford Foundation, the National Urban League and the University of Rochester. He served in the United States Navy, and he graduated from the University of Rochester in 1952 with a degree in business administration.

Louis J. Lanzerotti Dr. Lanzerotti, a Distinguished Member of the Technical Staff at AT&T Bell Laboratories and Adjunct Professor of Electrical Engineering at the University of Florida, has also served as Regents' Lecturer at UCLA. His principal research interests include space plasmas, geophysics, and engineering problems related to the impact of space processes on space and terrestrial technologies. He is a co-investigator and principal investigator on NASA missions, and conducts extensive ground-based and laboratory research on space-related topics. He was Chairman of NASA's Space and Earth Science Advisory Committee and is presently Chairman of the Space Studies Board of the National Research Council. Elected to the National Academy of Engineering and the International Academy of Astronautics, he is also a Fellow of the American Geophysical Union, the American Physical Society, and the American Association for the Advancement of Science. Dr. Lanzerotti has received NASA's Distinguished Public Service Medal. He has an engineering degree from the University of Illinois and A.M. and Ph.D. degrees in Physics from Harvard.

Thomas O. Paine Dr. Paine is Chairman of Thomas Paine Associates, a member of the National Academy of Engineering, and a Director of the Planetary Society, the National Space Institute, the International Academy of Astronautics, Orbital Sciences Corporation, the Pacific Forum, Quotron Systems (Division of Citicorp), and Nike, Inc. He joined the General Electric Research Laboratory in 1949, and in 25 years with GE served as Manager of GE's TEMPO (long-range technoeconomic studies), Vice President and Group Executive of the Power Generation Group (worldwide ship-propulsion, nuclear power and steam and gas turbine-generators), and Senior Vice President for Science and Technology (oversight of GE's research and development). During the first seven Apollo missions from 1968 through 1970, he was Administrator of NASA. From 1976 to 1982, he was President, Chief Operating Officer and Director of Northrop Corporation. Dr. Paine also has served as a Trustee of Occidental College and Brown University, and a Director of Eastern Air Lines, Arthur D. Little, RCA, and NBC. In 1985, President Reagan appointed him Chairman of the National Commission on Space, a panel created by the Congress to chart civilian

space goals for 21st-Century America. He received a Ph.D. in physical metallurgy from Stanford University in 1949.

Technical and Administrative Support:

James D. Bain, Committee Executive Secretary
James R. Beale, National Space Council Staff Liaison
Darrell R. Branscome
Laura J. Cooper
Edward A. Frankle, Committee Counsel and Ex-Officio Committee Member
Frances L. Gragg
Lauren B. Leveton
Delores L. McClung
John E. O'Brien, Ex-Officio Committee Member
George Reese, Committee Counsel
M. Ruth Rosario
Albert R. C. Westwood, Committee Consultant
Yvonne Williams

Appendix II

TERMS OF REFERENCE

ADVISORY COMMITTEE ON THE FUTURE U.S. SPACE PROGRAM

Purpose

The purpose of the Advisory Committee on the Future U.S. Space Program is to advise the NASA Administrator on overall approaches NASA management can use to implement the U. S. Space Program for the coming decades.

Task Statement

The Committee shall have a broad charter to:

- Review the future of the civil space program, including both management issues and program content.
- Assess alternative approaches and make recommendations for implementing future civil space goals, including such factors as:
 - Appropriateness of planned activities
 - Organizational balance and structure
 - Adequacy of overall skill base of work force
 - Balance between roles of government and private sector
 - Possible contributions by other government agencies
 - The need to maintain a strong R&D capability
 - Assurance of mission success

Schedule

The Committee shall report its findings within 120 days from the date of its inception.

Membership

The Committee shall be comprised of approximately 12 individuals selected for their knowledge of space activities and management expertise. Membership shall provide as broad a set of experience backgrounds as practicable. Ex-officio members may be added to the Committee upon approval of the Administrator of NASA with the concurrence of the Committee's chairperson.

Reporting Procedure

The Committee will operate as an independent entity, reporting to the Administrator of NASA, and will submit its findings to the Administrator of NASA

and, with the Administrator, to the Vice President of the United States, in his capacity as Chairman of the National Space Council.

Support

Administrative support will be provided to the Committee by NASA.

Legal Determination

Based on the objectives and purposes of the Task Force, the NASA General Counsel has determined that the activities of the Task Force fall within the scope of the Federal Advisory Committee Act (5 USC APP 1 et seq.). It is neither intended nor anticipated that any of the Board's activities will concern "particular matters" within the meaning of Section 208 of Title 18, U.S. Code.

Appendix III

LEGAL COMPLIANCE

Some members of the Committee, through their private employment, have interests in the aerospace community and, consequently, the activities of NASA. This factor was taken into serious consideration when they were appointed to the Committee and, pursuant to applicable laws, it was determined that the need for the individuals' services outweighed the potential for a conflict of interest. It was the further determination of the appointing authority that the private interests of the individuals appointed to the Committee were not so paramount as to impede their objectivity or integrity as members of the Committee. These determinations were made by the appointing authority only after coordinating with the office of Government Ethics to ensure full compliance with existing laws and regulations regarding the avoidance of conflicts of interest. A government attorney sat in on all sessions of the Committee at the request of the Committee Chairman.

In addition, the members of the Committee, recognizing there was an important concern as to avoiding even the mere appearance of a conflict of interest, endeavored throughout their Committee activities to minimize, wherever possible, any such possible appearance.

In this regard, because of his role as Chairman of the Committee and his position as a senior executive with an aerospace company, the Chairman of the Committee elected to disqualify himself from any decisions as to whether and how the Committee would address the issue of a new launch system. The deliberations and decisions as to this matter were handled by the Vice Chairman.

Appendix IV

WITNESSES

**(Individuals Appearing Before Advisory Committee
on the Future of the U. S. Space Program
and Its Working Groups)**

John Aaron
George Abbey
James A. Abrahamson
Brant Adams
Larry Adams
Clyde Albertgottie
Mark Albrecht
Arnold D. Aldrich
Buzz Aldrin
Ron Alexander
LaTonya Alexander
Lew Allen
Harold Ammond
Sam Araki
Hugh Arif
Sam Armstrong
Jack Arrison
F. Ron Bailey
Randy Baggett
Brad Baker
William F. Ballhaus-
Peter M. Banks
Richard W. Barnwell
David Barrett
Reginald Bartholomew
James E. Bartlett
Jeffrey E. Bauer
Robert C. Baumann
Brian Beckman
James Beggs
Joyce Bergstrom
William E. Berry
Mark Bethea
Vincent J. Bilardo
Nancy F. Bingham
David Black
Charles Bofferding
Albert Boggess
Daniel Boorstin
Carl O. Bostrom
Roland L. Bowles
Jeffrey S. Brady
Peter Bracken
Howard Branch
David Brannon

Porter Bridwell
Robert C. Bruce
James O. Bryant
Richard Bunevitch
Bonnie Buratti
Linwood G. Burcher
Peter T. Burr
Antonio Busalacchi
Lucinda Byrne
Gregory H. Canavan
Sandra Cargill
John Casani
Gerhard Casper
Frank J. Cepollina
Norm Chaffee
Moustafa Chahine
Elaine L. Chao
Charles R. Chappell
Michael Chilicki
Ronald Chinnapongse
A. Chutjian
Harlan Cleveland
Thomas Cochran
Aaron Cohen
Ray S. Colladay
James Colvard
Michael Comberiate
Dale L. Compton
Davis S. Coombs
Robert S. Cooper
John J. Cox
Harry Craft
Donald Cromer
Ray Cronise
A. P. Croonquist
Philip E. Culbertson
Frank Curran
Richard Darman
Charles R. Darwin
C. Calvin Davis
Rick Davis
Kirk Dawson
Clyde Dease
Hugh Dillon
Duane Dipprey

Peter Doms
Martin J. Donohoe
Regina Dorsey
Jeffrey C. Dozier
Robert E. Eddy
Charles Elachi
Donald Engen
George English
Roy S. Estess
Thomas Everhart-
Maxime Faget
Dale L. Fahnestock
David T. Fahringer
Christine M. Falsetti
James W. Fenbert
Harry B. Finger
Lennard A. Fisk
George Fleming
James C. Fletcher
Charles T. Force
Stuart Fordyce
David Francisco
Rosemary C. Froehlich
Robert Frosch
Cynthia Fry
Michael Fry
Robert Frye
L. L. Fu
Ann Fulton
Randy Furnas
Daryal Gant
Lori Garver
Steven W. Gayle
Riccardo Giacconi
Dawn Gifford
Stan Gill
Otto K. Goetz
William Goldsby
Robert E. Grady
Daniel Gregory
Jerry Grey
Angelo "Gus" Gustaferrero
Denton Hanford
Peggy W. Harmon
Roy V. Harris

Steven A. Hawley
 Norman Haynes
 Donald P. Hearth
 Buzz Hello
 Arthur Henderson
 Francisco J. Hernandez
 Noel Hinnens
 Wendy Holladay
 Harry C. Holloway
 Paul F. Holloway
 Richard B. Holt
 Stephen S. Holt
 Jay Honeycutt
 Ralph M. Hoodless
 W. Ray Hook
 Thomas J. Horvath
 Thomas R. Huber
 Kenneth R. Human
 Carolyn L. Huntoon
 Dale Hupp
 William F. Huseonica
 Jeffery C. Hyle
 Rene Ingersoll
 Thomas Irvine
 Martin H. Israel
 Roger L. Jenkin
 Linda M. Jensen
 Michael Johnson
 Stephen Jung
 Said Kaki
 Samuel W. Keller
 Cynthia Kelly
 Regina Kelly
 Eugene L. Kelsey
 Satish Khanna
 George H. Kidwell
 Jenny S. Kishiyama
 Ray Kline
 John M. Klineberg
 Martin A. Knutson
 Chester Koblinsky
 John Koudelka
 Robert Kozar
 Michael Krainak
 Martin P. Kress
 S. M. Krimigis
 Donald J. Kutyna
 Alan Ladwig
 Cynthia C. Lee
 Robert B. Lee, III
 Thomas J. Lee
 William B. Lenoir
 Byron P. Leonard
 Gale Lewis

LeNoir Lewis
 Morris L. Lile
 Bruce D. Little
 Jane Liu
 John Logsdon
 Rebecca J. Lowe
 William R. Lucas
 Henry Lum, Jr.
 Valerie Lyons
 Christopher P. Mackay
 Robert Mackin
 Jeremiah J. Madden
 Gray Marsee
 Rebecca McCaleb
 Forrest McCartney
 Roslyn L. McCreary
 Helen McConnaughey
 John McElroy
 Joseph T. McGoogan
 John L. McLucas
 Ann Merwarth
 James F. Meyers
 Roger Meyers
 Lon F. Miller
 Royce E. Mitchell
 Herbert Mittelman
 Tom Moore
 David Moore
 Thomas Moorman
 James R. Morrison
 Walter E. Morrow
 George Morrow
 Bruce Murray
 Thomas J. Murrin
 Dale D. Myers
 Roger Myers
 Joyce Neighbors
 Norman F. Ness
 William C. Nettles
 James C. Newman, Jr.
 Jerry R. Newsom
 Thomas E. Noll
 John E. O'Brien
 Edward O'Connor
 Michael O'Neal
 Michael Oben
 Arthur F. Obenschain
 James B. Odom
 David Olney
 O. J. Orient
 Angel Otero
 Thomas O. Paine
 Don Palac
 S. Paul Pao

Sidney F. Pauls
 Vicki Pendergrass
 C. Perigaud
 Richard H. Peterson
 Victor L. Peterson
 James Phillips
 David R. Picasso
 Andy Pickett
 Sasi Pillay
 Kevin Plank
 Alexander Pline
 Don Polac
 Sam Pollard
 Lamont R. Poole
 Fred Povinelli
 Lonnie Reid
 Kerry Remp
 Leonard Ricks
 William E. Robbins
 Linda Robeck
 Ralph H. Robinson
 Neal Rodgers
 Thomas F. Rogers
 James T. Rose
 Stan Rosen
 Lawrence J. Ross
 Joseph H. Rothenberg
 C. T. Russell
 Stephen M. Ruffin
 George Russell
 Kurt Sacksteder
 Carl Sagan
 Vincent V. Salomonson
 Stanley Sander
 Neal Sanders
 Stephen P. Sandford
 Pat Scheuermann
 B. A. Schriever
 Christopher J. Scolese
 John P. Scully
 Robert C. Seamans, Jr.
 Michael G. Shafto
 Willis H. Shapley
 Joseph C. Sharp
 Kirk Sharp
 Brewster Shaw
 Joe Shaw
 Joseph Shea
 Thomas A. Shull
 Richard J. Siebels
 Robert Sieck
 Bill Sikora
 Allan Silver
 Louis E. Simmons

J. A. Simpson
Joel R. Sitz
James Slavin
Nancy E. Sliwa
Mike Smiles
L. Dennis Smith
Gerald Smith
Richard Smith
Michael D. Smock
D. Thomas Snyder
Robert Snyder
Kenneth A. Souza
Roy Spencer
Joel Sperans
Suzanne Spitz
Russ Springham
Robert Staehle
Anne K. St. Clair
Thomas Stafford
Angela Stewart
Andrew Stofan
Edward C. Stone
Anthony Strazisar
William Strobl
Robert L. Swain
Clarence "Cy" Syvertson
Steve Szabo
Michael E. Tall
John Taylor
William F. Taylor
Thomas D. Taylor
Samuel M. Tennant
Charles E. Thienel
A. S. W. Thomas
Gene Thomas
Ron Thomas
Walter Thomas
John D. Thompson
J. R. Thompson, Jr.
Marco Toral
Carmen O. Torres-Nisbet
John Townsend
James H. Trainor
Paivi Tripp
Richard H. Truly
Susan Turner
Daniel Tweedt
Donald Urasek
James A. Van Allen
Joan Vernikos
Edgar G. Waggoner
Carrie K. Walker
Jerry Wall
Joyce Wanhainen

Sandy R. Webb
Mark Weislogel
Martin Weisskopf
Vern Weyers
Douglas W. Whipple
David R. White
John White
Lynne White
David Whitten
Alan W. Wilhite
C. Wayne Williams
Charles Williams
Keith Wilson
Murray J. Wilson
Fred S. Wojtalik
Lowell Wood
Jerry Wood
Timothy G. Wood
William H. Wood
James Woods
John F. Yardley
John Yin
Tom Young
V. Zlotnicki
Henry N. Zumbrun

Appendix V

BIBLIOGRAPHY

- American Institute of Aeronautics and Astronautics. **U.S. Civil Space Program: An AIAA Assessment.** March 1987.
- Bilstein, Roger E. and Frank W. Anderson, Jr. **Orders of Magnitude: A History of the NACA and NASA, 1915-1990.** NASA SP-4406. 1989.
- Byerly, Jr., Radford. (ed.) **Space Policy Reconsidered.** Westview Press. 1989.
- Center for Strategic and International Studies. John H. McElroy and Brent Scowcroft, Chairmen. **A More Effective Civil Space Program.** May 1989.
- George C. Marshall Institute. **New Directions in Space: A Report on the Lunar and Mars Initiatives.** 1990.
- National Academy of Public Administration. Samuel C. Phillips, Chairman. **Effectiveness of NASA Headquarters: A Report for the National Aeronautics and Space Administration.** February, 1988.
- National Academy of Sciences, National Academy of Engineering, Committee on Space Policy. H. Guyford Stever, Chairman. **Toward a New Era in Space: Realigning Policies to New Realities, Recommendations for President-Elect George Bush.** National Academy Press. 1988.
- National Aeronautics and Space Administration (NASA), Advisory Council, Life Sciences Strategic Planning Study Committee. Frederick C. Robbins, Chairman. **Exploring the Living Universe: A Strategy for Space Life Sciences.** 1988.
- NASA, Advisory Council, Space and Earth Science Advisory Committee. **The Crisis in Space and Earth Science: A Time for A New Commitment.** November 1986.
- NASA, Advisory Council, Task Force on International Relations in Space. **International Space Policy for the 1990's and Beyond.** October 1987.
- NASA, Advisory Council. John L. McLucas, Chairman. **Report of the Task Force on Space Transportation.** December 1989.
- NASA, Center Science Assessment Team. D. James Baker, Chairman. **Science at NASA Field Centers: Findings and Recommendations on the Scope, Strength, and Interactions of Science and Science-Related Technology Programs.** May 1988.
- NASA, History Division. **Evolution of the NASA Institution.** January 1988.
- NASA, Office of the Administrator. **Results of the Life Support Management Working Group, Volumes I and II.** June 1989.
- NASA, Office of Aeronautics, Exploration and Technology. **Space Exploration Initiative: Technology Needs and Plans; A Report to the U. S. Senate.** Summer 1990.
- NASA, Office of Exploration. Annual Report to the Administrator. **Beyond Earth's Boundaries, Human Exploration of the Solar System in the 21st Century.** 1988.
- NASA. **Report of the 90-Day Study on Human Exploration of the Moon and Mars.** November 1989.

NASA. Samuel C. Phillips, Chairman. **Summary Report of the NASA Management Study Group: Recommendations to the Administrator.** December 1986.

NASA. Sally K. Ride. **Leadership and America's Future in Space.** Report to the NASA Administrator. August 1987.

National Commission on Space. **Pioneering the Space Frontier.** Bantam Books. May 1986.

National Research Council (NRC), Committee on Human Exploration of Space. **Human Exploration of Space, A Review of NASA's 90-Day Study and Alternatives.** National Academy Press. 1990.

NRC, Space Science Board, Committee on Space Biology and Medicine. Jay Goldberg, Chairman. **A Strategy for Space Biology and Medical Science for the 1980's and 1990's.** National Academy Press. 1987.

NRC, Space Science Board. **Space Science in the Twenty-First Century: Imperatives for the Decades 1995-2015, Overview.** National Academy Press. 1988.

NRC. **U.S. Global Change Research Program, An Assessment of the FY 1991 Plans.** National Academy Press. 1990.

Truly, Admiral Richard H. **A Statement to Subcommittee on VA-HUD-Independent Agencies, House Committee on Appropriations.** March 1990.

U.S. Congress. **National Aeronautics and Space Act of 1958, as Amended.** (PL-85-568, 85th Congress, H.R. 12575. August 29, 1958. 72STAT426.) January 1990.

U.S. Department of Commerce. **Commercial Space Ventures: A Financial Perspective.** April 1990.

U.S. Department of Defense, Office of the Under Secretary of Defense for Acquisition. **Report of the Defense Science Board, 1989 Summer Study on National Space Launch Strategy.** March 1990.

U.S. President's Pay Agent (Advisory Committee on Federal Pay) Annual Report. **Comparability of the Federal Statutory Pay System with Private Enterprise Pay Rates.** 1989.

U.S. Presidential Commission. William P. Rogers, Chairman. **Report of the Presidential Commission on the Space Shuttle Challenger Accident.** June 1986.

U.S. Space Task Group. **Report to the President: The Post-Apollo Space Program: Directions for the Future.** U.S. GPO. September 1969.

White House, Office of the Press Secretary. Fact Sheet. **Commercial Space Launch Policy.** September 1990.

NATIONAL SPACE COUNCIL
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20500

Ed Rogers,

Ed

Attached is a memo for the VP
providing a status update on
the Augustine panel re: US
civil space program.

These "preliminary discussions" are
very preliminary and, obviously very
sensitive.

Please keep this close hold
between you & Gov. Jaramila.

Best
Mark

NATIONAL SPACE COUNCIL
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20500

November 8, 1990

MEMORANDUM FOR THE VICE PRESIDENT

FROM: MARK J. ALBRECHT 
SUBJECT: Status of the Space Advisory Committee

Norm Augustine's Committee is beginning to reach conclusions. While still very preliminary, it looks like their recommendations will involve significant changes in both current programs and the internal management of NASA. Probably the most remarkable result so far has been the degree of consensus among the Committee members. I have attached some Committee working papers which outline their current thinking. Some of the tentative findings are:

- o Manned missions to Mars are inevitable and a proper objective for the civil space program but the schedule needs to be relaxed to allow exploration to proceed at a steady and affordable level of funding.
- o Don't buy any more space shuttles. We need to make the current shuttles work, focus them on carrying people and begin development of another launch vehicle to carry cargo.
- o Continue the space station but reconfigure it to be more evolutionary, less dependent on the shuttle and more realistic in terms of cost, schedule and performance.
- o Change NASA's management structure, both within headquarters and in the way programs are assigned to and managed by the NASA centers in order to increase accountability and predictability and reduce government overhead.

Attachment
Tab A: Preliminary Discussions

PRELIMINARY DISCUSSIONS

RESOLVE SEI

- Manned Mars is inevitable --- only timetable is issue
- Steady-state funding --- flexible schedule
- Must have Space Station (life sciences)
- In Parallel
 - Robotic Missions to Mars
 - Colonize Moon

TRANSPORTATION

- Must make Shuttle work -- dependent upon it for a decade+ of manned space flight
- Focus Shuttle on man-related missions
- Begin an unmanned launch vehicle to support Space Station and do truck missions and if possible do SEI first stage
- Don't buy 6th orbiter
- Revalidate need for ASRM (if go with Shuttle-C)
- Build (AF/NASA) technology for HLV -- go do new engine
- Nuclear stage technology
- New launch vehicles must support DOD and NASA
 - Purpose:
 - More payload for Space Station
 - First stage for Moon and Mars
 - Back-up Shuttle as a truck
 - Save \$
- Country civil space program needs a new heavy lift LV capability
 - AF and NASA together (only one family)
 - Use:
 - Parallel Shuttle
 - Space Station
 - SEI
 - Stable funding -- long-term commitment; Fence the resources

SPACE STATION FREEDOM AS STARTING POINT

- SSF is important element
- SSF program must be reconfigured to comport with budget realities, support long-range space goals, and increase confidence level
 - Mission priority:
 - Learn to live and work in space
 - Life Sciences/Life Support
 - Microgravity (clearly second)
(Look at near term alternative sources for some of data)

(Not justified by science, not transportation node, not manufacturing)

- Work with international partners on any changes
- See evolutionary approach to achieving goals
 - (1) Earlier limited use
 - (2) Flexibility for growth
- Reassess match of SS assembly to launch vehicle strategy
- Reconfigure program to introduce more margin (conservatism) (power, weight, cost, schedule, complexity)
- Reduce Shuttle dependence insofar as practicable

SPACE STATION MANAGEMENT

- Problem: Management overload, lack of systems engineering, geographically dispersed and fragmented
- Recommendation: Correct problem above. A possible model is:
 - 1. Carefully consider providing dedicated management to Space Station and Shuttle with both reporting to Administrator
 - 2. Establish at Houston a project management office (not under JSC management) with OWN staff
 - Strengthen systems engineering capability with JSC people (and contractors if required)

GENERAL MANAGEMENT

- Criteria: Should be able to answer readily
 - 1. Who is in charge (responsible)
 - 2. Do they have necessary authority and resources
 - 3. Are requirements separate from implementation
- In General: Design programs to minimize inter-center and contractor interfaces
- Prefer lead center concept when more than one center has major role
- Don't do day-to-day project management of major programs from Headquarters
- Reduce diversification of centers; Establish Centers of Excellence
- FCRC systems concepts and analysis support at Headquarters
- Stronger independent cost estimating (civil service)
- Also need a need a ten-year cost plan
- Have new AA for Exploration (manned and unmanned)

PERSONNEL

- Premise: To undertake challenging space program, NASA must have share of nation's most capable people.
- Problems:
 - Civil service constraints
 - Lack of leavening with new blood at middle and higher level

- (conf. of int.)
- Discouragement from oppressive management system
- Lack of clear change for "victories"
- Solution:
 - Preferred: "Fix" civil service (make NASA a lead "path-finding" agency for advanced personnel management)
 - Salaries
 - Hire/Fire
 - Move (cost covered)
 - Pay for performance
 - Real bonus system
 - Double dipping in critical cases (?)
- If Not:
 - Limited exceptions for key NASA positions, e.g., 10% and
 - Phase some centers to JPL model; First Ames, then perhaps Langley and Lewis
- Need
 - Career development program (enhance)
 - Scholarship Program (Holloway)
 - China Lake experiment
 - "NRL" support for colleges

INTERNAL MANAGEMENT APPROACH

- Must have in-house hands-on expertise
- But should focus on leading edge, long-term, "infrastructural" tasks not available elsewhere (University and Industry)
- Not reasonable nor appropriate to expect significant increase in NASA civil service staffing (in spite of NASA's desire)
- Contract out more on a prime basis those space elements where industry and academia have capabilities (more analogous to national security space program) (Examine Government rule as integrating contractor)
- Civil servants focus on advanced technology and critical contract monitoring
- Tie report to external responsibilities
 - Education
 - Competitiveness
 - Motivation

EXTERNAL: Oversight of NASA

- Space Council sound structure but role is policy not management
- Don't create a new agency (a la SDI) --- NASA is the civil space focus --- make it work
- Make NASA Administrator "DCI" of all civil space
 - NASA does development and NOAA as operator, funder and must learn to procure hi-tech
 - Launch vehicles joint with DOD

NOTE: NASA has a NACA responsibility in space...for technology (not always operation)...ATC, Wx, Comsat, ...

EXTERNAL: CONGRESS

- Congress - managing long-term programs
 - Congress could help by:
 - Need a consensus on goals and affordability
 - Help provide funding stability (agency and OMB, also)
 - Civil Service
 - Procurement policy
 - NASA must provide more realistic cost information to Congress including launch and operations, including margins
 - NASA should seek to fund/budget more by project and function and less by infrastructure elements
- Note: NASA needs a "TYNP" (NASA "FYDP")

SCIENCE, TECHNOLOGY, AND APPLICATIONS

- Science Program is good, but
 - Execute the strategic plan
 - Science/technology program of approximately current % level gets first priority for NASA dollars
 - Establish fast-track procurement process for small activities
 - Use universities as primes more often, if they wish and are capable
- Management: Augment current accounting system to provide much greater visibility into total cost of projects. Allocate costs to end item insofar as possible. This does not necessarily require changing the day-to-day budgeting system.

EXTERNAL RESPONSIBILITIES

- Premise: NASA has responsibilities beyond flying its missions
 - Strengthening Education -- Seek to put work in universities
 - Enhance Technological Competitiveness of U.S.
 - Encourage technology transfer
 - Put meaningful work in industry wherever excellence exists
- Notes:
 - The NACA and NASA model in aeronautics is an outstanding example of government helping the private sector build premier competitive positions. This should be done for space.
 - NASA becoming competitive with U.S. industry is the wrong model

OPERATIONS

- Problem: Repetitive operations, especially shuttle, likely to take increasing portion of NASA time away from leading-edge activities, but.....
- Shuttle is manned (with all that entails), largely non-routine, relatively fragile, and critical to the U.S. space program
- Hence
 - Establish dedicated AA for shuttle operations reporting directly to Administrator
 - This can be core of a future operations organization (which can also provide input to future designs)
- In meantime, seek to reduce gradually manning support of launches
- In long term future, launch systems design should be compatible with spinning mature, repetitive operations out of NASA to others, e.g., industry, government corporation, etc.

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President's Space Summit
Draft Talking Points for the President
4-16-90

- Good morning, and welcome.
- I asked to meet with you today to talk with you -- and to listen to you -- about something vital to our nation's future, including our children's future -- our space program.
- Let's talk about where the space program should be headed, and how we might join together to set a strategy to get us there.
- Our national space program is based on the long-standing premise that it is vitally important to maintain American leadership in space.
 - This leadership advances our national security, foreign policy, scientific, and economic interests. Leadership ensures a vigorous, aggressive, and forward-leaning space program.
- Investment in space is one of the best single investments we can make. There are real and tangible benefits:
 - For our generation, it has revolutionized communications and computerization, and created thousands of industrial materials and medical advances.
 - For our children and grandchildren, it will continue to do all this and more -- for example, space holds the promise of being the ultimate and long-sought source of clean, abundant, and safe energy.
- More specifically, advances in space technology keep us competitive in an increasingly competitive world:
 - It pushes education.
 - It creates jobs.
 - Space technology spinoffs create new businesses and new markets that we can't afford to lose to the Japanese and the Europeans, both of whom are catching up with us.
 - All of these space benefits create a higher quality of life for all Americans.
 - They also brighten America's beacon of hope to developing nations of the world, including Eastern Europe.

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- Space is a showcase of U.S. economic, military, and moral leadership in the world.
- Finally, space cooperation plays an ever-increasing role in promoting international goodwill, peace, and stability.
- I've put before the Congress a large increase in military and civil space spending from roughly \$29 to \$33 billion for FY 91. That includes an increase for NASA from \$12.3 to \$15.2 billion.
- It supports several of our program priorities:
 - First, Space Station Freedom -- America's laboratory for advanced space research, and our post-2000 outpost for human exploration of the Solar System in the next century. It is imperative that we find funding this year to keep this program moving forward.
 - Mission to Planet Earth -- America's new initiative to understand and chart ways to curb the ecological abuses that we and all humanity are heaping upon the Earth.
 - The Moon-Mars Initiative -- America's return to human space exploration that will allow us to push on with the job that the Apollo Program began.
- So this is why we need to press forward. This is why I asked the Vice President to head the new National Space Council and to formulate this aggressive and much needed step into our nation's future.
- Dan, why don't you take a few moments and brief everyone on where we stand on the work of the Space Council.

(Vice President speaks for 3 minutes)

- Thank you, Dan. As you can see, we have a dynamic, integrated, and visionary space program to carry this country forward into the 21st Century.
- I know there are many competing priorities, but we simply must find ways to keep it on track and moving vigorously ahead.
- (Discussion)

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President's Space Summit
Draft Talking Points for the Vice President
4-16-90

- Thank you, Mr. President.
- With your strong support, and that of many Congressional leaders here today, the National Space Council has moved ahead vigorously during its first year of operation -- essentially along three tracks:
 - First, a rescue effort to keep vital programs going -- We've found ways to save the remote sensing LANDSAT program, the National Aero-Space Plane, and to lend support to the Space Station program.
 - Second, a long-range plan to provide much-needed leadership, sharp focus and real pay-off for the U.S. space program as we head into the next century.

Keys here are Mission to Planet Earth and your Moon-Mars Initiative -- your goal of returning to the Moon to stay, and sending manned expeditions to the planet Mars.
 - Third, development of a comprehensive strategy for the entire space program that provides a rational and balanced framework for all space activities.
- In carrying out these activities, we are emphasizing several priorities:
 - A balanced mix of manned, and unmanned, scientific, and exploratory missions. This is the strong backbone of our space program.
 - Pursuit of our initiatives in ways that -- in a phrase that says it all -- are "faster, better, cheaper, and safer." This means creativity, imagination, and excellence -- it also means challenge, risk, and even occasional failure.
 - Pushing space technology in ways that will keep this nation on the cutting edge of space leadership and technological competitiveness.
- Finally, a few words about the President's Moon-Mars Initiative.
 - Why are we doing it? Why have we ever done anything that is so fundamentally in our national interest, that continues the countless benefits of the space program and sends them to every part of our national security, foreign policy, scientific, technological, and economic

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well-being.

- What's the approach? We need a modest \$180 million in FY 91 to begin the technology development that will lead to alternative ways for better, faster, cheaper, safer ways of achieving our goals on the Moon and Mars. This is not a new program start. It is instead the beginning of a 2-3 year technology development effort leading to a better understanding of what's involved. This may ultimately save us ten times over its actual cost.
 - What does this buy us? It buys answers to our questions: What, How, How Much, When, etc. That is, the best and most cost-effective ways of going back to the Moon and on to Mars. It will tell us the best, fastest, cheapest, and safest way to do it.
 - What are we asking for? We are asking for money and time to answer the critical questions the President has put before the nation. Can we feasibly achieve our goals? What are the alternative approaches? How much will they cost? How long will they take? What ideas do other spacefaring nations have? Can we make this a comprehensive effort? We are not asking the Congress to commit to a program this year. What we are asking for is money to answer these and other questions fundamental to our understanding of our options and possible approaches.
 - What are the effects of denying the funding? Let me make it very clear: Denial of the funding is akin to killing the Moon-Mars Program. This is because the funding provides the basis for understanding the cost and approach that will be required -- the very data essential for making sound decisions in 2-3 years on whether to undertake and fund the exploration program. So, denial of the technology development funding -- \$180 million in FY 91 -- effectively kills the Moon-Mars Initiative.
- So we need your support for the President's space program. We know it is not easy to find the funding. But a great nation has many goals.
- Thank you.

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Background for Congressional "Space Summit" 4-16-90

Objective

The purpose of the meeting is for the President to show support for the FY 91 space budget by calling an unprecedented meeting with the House and Senate leadership. Secondly, its purpose is to support the Space Exploration Initiative (Moon-Mars), the President's major new space initiative. Being a new program -- and the President's program -- it is an obvious target for cuts.

General Background

Since the Apollo program, the civil space program has had little active or demonstrable Presidential support. Prior to President Bush, no recent President has given high priority to space. It has been kept alive largely through an alliance of a handful of Congressmen and a succession of top level NASA officials and center directors.

This budget cycle will put a major stress on the ability of that alliance to deliver on the Administration request. First, because the President's request is for a 24% increase for NASA, the largest percentage increase for any government agency. Second, last summer the President announced a new space initiative (Moon-Mars) which, like any new initiative, will require careful nurturing to survive.

There has not been a Presidential meeting with the Leadership specifically devoted to space in at least a decade. Senators Garn and Mikulski have been asking for some kind of a conference with the President since last year, so this meeting is, in part, a response to their request.

Invited members of Congress include:

Leadership:

Senate: Mitchell and Dole
House: Foley and Michel

Civil Space Authorizing Committees:

Senate (Commerce, Science, and Transportation):
Hollings and Danforth
House (Science, Space, and Technology):
Roe and Walker

Appropriations:

Senate: Byrd and Hatfield
House: Whitten and Conte

Appropriations Subcommittees:

Senate (HUD, VA, Independent Agencies):
Mikulski and Garn

House (HUD, VA, Independent Agencies):
Traxler and Green

The Current Situation

The current thinking on the Hill, absent a negotiated arrangement with the Administration, is that the budget allocation for NASA and science and technology -- Function 250 -- will take a \$1 billion cut. Further, the lion's share of this would come out of the NASA budget since the FY 91 requested increase is so large (a \$2.9 billion or 24% from \$12.3 billion to \$15.2 billion).

Of that \$2.9 billion increase, \$180 million of new money is dedicated to the Moon-Mars Initiative. (Of the \$1.3 billion total aggregated under the Moon-Mars initiative, the remainder is for ongoing programs like National Aerospace Plane and the Advanced Launch System.) By contrast, \$1 billion of this \$2.9 increase is for the Shuttle program, \$700 million is for Space Station, and \$200 is for Mission to Planet Earth, a new start.

On the Senate side, the two subcommittee appropriators -- Senators Garn and Mikulski -- are generally supporters of the civil space program. Especially in Mikulski's case, this support has come at the expense of strong support for housing and veterans programs which compete for funds in that subcommittee. Though both Garn and Mikulski have given support to the general desirability of human space exploration, they think it's a pretty large frog to swallow in a difficult budget year, in the face of a \$1 billion cut. Both are sending early signals that the Moon-Mars program is extremely vulnerable absent strong intervention by the White House.

The House side is a little rougher. Congressman Green is not only unsympathetic to the Moon-Mars initiative, he is opposed to manned space programs in general, including the Space Station. Traxler's position is more flexible, but still difficult. Fighting off competing demands from veterans and housing is a challenge in his subcommittee. In addition, he is said to be squeamish about arguing the merits of space exploration to his constituents in Michigan when "the highways are falling apart."

Space Station is also vulnerable to cuts, in part because of recent attention focused on future operations and maintenance costs. Over the past few weeks, internal NASA reports have surfaced that put current design requirements for extra-vehicular activity (EVA) at over ten times the optimal amount.

Mission to Planet Earth, on the other hand, is less vulnerable to large cuts since it has been more of a "congressional" initiative.

The Moon-Mars Initiative

The Space Exploration Initiative began with the President's speech on July 20, 1989 commemorating the 20th Anniversary of the Apollo 11 Moon landing. Its objectives are to return to the Moon to stay and then send manned missions to Mars and beyond. In that speech, the President tasked the Vice President to lead the National Space Council in determining specifically what the program would require, including cost and schedule, and the feasibility of international cooperation for this program.

The President has recently approved two sets of policy decisions for the initiative, the first outlining the approach to the program design, and the second outlining the approach to international cooperation.

The President's decisions on the program approach will give early focus to technology development and will include investments in high leverage innovative technologies. Further, the program will take at least several years defining two or more significantly different reference architectures. This approach might lead to breakthroughs in technology which could significantly improve the cost, schedule, and risk profile that would otherwise result from using technology available today. The President's program approach also called for the involvement the Departments of Defense and Energy -- in addition to NASA -- in order to ensure consideration of the widest possible array of technical alternatives.

The President's decisions on international cooperation in space exploration were that it is feasible and could provide significant benefits. This cooperation will begin with a dialogue with other space-faring nations including the USSR. Many in Congress have supported international cooperation as the way to lower overall cost for the program. Indeed, some have said that the only exploration program they would support is an international one.

Space Station Freedom

FY 91 is the year actual construction of Space Station Freedom begins. The Station budget request calls for an increase to \$2.6 billion from a 1990 level of \$1.9 billion. In order to retain the schedule for first element launch in 1995, NASA will need essentially the entire request. If significant cuts are mandated the schedule will, in all probability, be delayed.

Such a delay would not only increase the overall cost, but would have severe ramifications for our Space Station partners (Europe, Japan and Canada). Significant pressure was placed on Congress

last year to maintain funding. However, Congress cut about 10% from the Administration's request. The resultant rephasing of the Station construction schedule caused our foreign partners considerable concern which they made known through high level diplomatic channels.

The Station budget will be particularly difficult to maintain this year in light of recent public controversy surrounding our ability to maintain the Station once it is built. NASA had identified in March a potential maintenance problem, which they believe is serious but under control.

Mission to Planet Earth

The Mission to Planet Earth program is designed to obtain data from spacecraft which can be used understand the earth's environment, predict negative changes caused by manmade and natural sources and from this understanding devise solutions to those problems.

Mission to Planet Earth is part of the \$50 billion, 25 year U.S. Global Change Research Program. It is also the most expensive portion, representing over 75% of the cost. In FY 1991 the Administration has requested an increase from \$415 million to \$636 million for Mission to Planet Earth. The bulk of this increase is to begin a new start on the Earth Observing System, a series of large satellites which form the heart of the Mission to Planet Earth program -- the first of which is scheduled for launch in 1997. Congress is very supportive of this program, but some members question whether the satellite observations cannot be made sooner and more cheaply. The National Space Council is conducting a study to determine the best and fastest approach to answering environmental questions from space.

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Status of Exploration Outreach Program April 16, 1990

NASA has prepared and coordinated their proposed outreach program with Space Council staff. The objectives of the Outreach program are to solicit the widest possible range of inputs, synthesize the inputs and produce a several year program plan by the fall. This plan will include at least two alternate architectures to be examined and validated for the next several years, a technology development program to pursue the most promising cost reduction and increased performance approaches, and a set of near term technical milestone experiments which will show visible progress.

The outreach effort is divided into two overlapping phases. The first is designed to solicit technical and concept inputs and collate these for analysis. The second phase will synthesize the inputs and come up with a coherent program plan.

The solicitation phase will involve three efforts. The first has already begun and it consists of a program managed by the American Institute of Aeronautics and Astronautics (the key technical aerospace engineering society in the country) to solicit ideas from the members. This effort will culminate in a technical meeting in late summer. The second effort will involve a NASA-led interagency team to visit and identify all government lab efforts which may be relevant to space exploration. The third will involve a public solicitation to industry as well as private individuals to be run and coordinated by the RAND Corporation.

The three solicitation efforts will feed into a synthesis "commission" consisting of the best and brightest U.S. experts. This will involve both government and non-governmental experts and will be chaired by someone outside NASA.

All of these efforts will be multi-agency, but led by NASA. NASA has coordinated their plan with staff from DOE and DOD. In the next few weeks NASA Administrator Truly, DOE Secretary Watkins, and DOD Deputy Secretary Atwood plan a meeting with the Vice President to finalize the plan.

This plan is identical to the approach recommended by the Aerospace Industries Association -- who were tasked by the Vice President to recommend the best approach.

Funding for the outreach and synthesis effort is a problem. The total cost for FY 1990 will be about \$3 million. Although NASA officials had promised Space Council staff that they had the necessary resources in January, these were committed to further work at the Johnson Space Center. One approach now would thus have been to reprogram money from other NASA programs. However, this would have required Congressional approval of the reprogramming. In order to avoid the reprogramming, NASA chose to use existing exploration-related funds in the Pathfinder

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technology line and to recall some of the funds committed to Johnson Space Center activities. They also reduced the money requirements by holding off on contracts to support internal studies.

NASA officials did believe, however, that they should inform Congress of their plans. NASA staff briefed Congressional staff last week. Appropriations Committee staff, particularly in the House strongly objected to NASA's actions, claiming that the outreach was a new activity which Congress had never authorized and which did require a reprogramming. NASA and OMB believe that this is not the case, but are reluctant to anger Congress in light of other requests they are making such as for supplemental resources to cover pay requirements. Admiral Truly intends to call Congressman Traxler and Senator Mikulski personally to persuade them to relent in their opposition. However, this effort may well fail.

While Congress' position is relatively weak on the argument that exploration is a new activity, their case is not based on legality arguments. Rather, Congressional staff have told Space Council staff that they simply do not want us to start the exploration outreach. They fear that the outreach program will "stir up" the technical community to pressure Congress to proceed with the exploration program. This in turn will present Congress with an even worse problem in finding funds for other NASA programs such as Space Station Freedom.

A solution to the dilemma would be to convince key Congressional leaders that the exploration program is of highest priority to the President and Vice President. To this end a "Space Summit" has been scheduled with Congressional leadership and the President and Vice President on Wednesday, 18 April.

NATIONAL SPACE COUNCIL
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20500

March 22, 1990

MEMORANDUM FOR THE POLICY AND IMPLEMENTATION REVIEW COMMITTEE

FROM:

MARK J. ALBRECHT

SUBJECT:

Commercial Space Launch Policy and Strategy Review

At the March 19, 1990 meeting to the National Space Council, the Vice President directed that a review of commercial space launch policy implementation be completed by June 1, 1990 to provide a context for considering issues associated with growing non-market competition. The working group established to assess issues associated with the proposed spaceport at Cape York, Australia will undertake this review under the guidance of the PIRC. A draft task statement for the review is attached. It will be coordinated through the working group over the next several days and a final version provided to you within about ten days.

The scope of the ad hoc working group's activities have been expanded somewhat and you may wish to modify your agency's representation accordingly. However, as this will be a very fast paced review, I ask that you restrict your agency's participation to no more than two representatives and insure that those representatives are able to accurately reflect your views and those of your Space Council principle.

This review will be closely coordinated with the National Space Council's ongoing reviews of commercial space policy implementation and national space launch strategy. We had intended to address the commercial space launch issues within the context of those two reviews but time constraints associated with the acceleration of the schedule make that infeasible.

If you have any questions please contact me.

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- o Consider national security, economic, trade and foreign affairs implications.

3. Based on the findings of the previous phase, define policy and strategy alternatives to achieve the U.S. national interest relative to the U.S. commercial space launch industry. These alternatives should be sufficiently broad to provide a policy framework for considering future issues associated with:

- o U.S. Government investments in support of the commercial space launch industry.
- o Rules of the road negotiations with ESA or other governmental entities relative to the provision of space launch services.
- o Non-market competition including the sale of Soviet and PRC space launch vehicles or launch services, launched either from those countries or from third countries such as Australia or Brazil.
- o International sale or transfer of space launch vehicles or means of production.
- o U.S. government procurement of space launch vehicle hardware and space launch services.
- o Commercially provided space infrastructure, both U.S. and foreign.

4. Analyze these alternatives in terms of:

- o Implications for achieving the national security, foreign affairs, economic and trade objectives of the United States.
- o Implications for the U.S. satellite manufacturing industry, the telecommunications industry and other U.S. space-related industries.
- o Implications for ballistic missile proliferation.
- o Implications for the transfer of critical or sensitive technologies.

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TASK STATEMENT

COMMERCIAL SPACE LAUNCH POLICY REVIEW

The ad hoc working group will review implementation of current commercial space launch policy and will develop policy and strategy alternatives for consideration by the National Space Council. The review will:

1. Describe the current state of the United States commercial space launch industry.

- o Corporate involvement and current and projected capabilities and limitations.
- o Estimated level of private sector investment and current and planned government supports.
- o Current and projected market for United States ELV's.
 - United States government payloads.
 - Foreign or commercial payloads for which the U.S. industry is competitive.
- o Foreign competition.
 - Current and projected capabilities and limitations.
 - Estimated level of private investment and government supports.
 - Unique markets such as foreign government owned satellites or other payloads which, for political reasons, will not be available to the U.S. industry.
- o Characterize the current and projected competitiveness of the U.S. commercial space launch industry on the international market for non-U.S. government payloads.
 - Define competitiveness and identify the criteria by which it can be measured.

2. Determine if the U.S. national interest is best served by relying, to the maximum extent feasible, on the private sector provision of launch services. If so, determine if that national interest extends to insuring that the industry achieve, or maintain, any particular level of competitiveness in the non-governmental market.

Withdrawal/Redaction Sheet

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05c. List	Policy Implementation Review Committee [Name redacted] (1 pp.)	3/22/90	(b)(3)	

Collection:

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Series: Rogers, Edward
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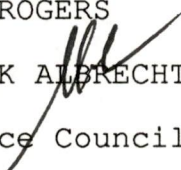
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The Honorable John Tuck

NATIONAL SPACE COUNCIL
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20500

March 13, 1990

MEMORANDUM FOR ED ROGERS

FROM: MARK ALBRECHT 
SUBJECT: Space Council Update

As I promised, in order to keep you informed of Space Council activities, I enclose here a few things you might find of interest:

1. A copy of the press release announcing the President's program policy decisions for the Space Exploration Initiative, and a copy of the decision memorandum.
2. A National Research Council report issued last week, prepared at the request of the Vice President. He had asked the NRC to prepare an assessment of the contents of the NASA 90-day study on the Space Exploration Initiative.

The report is wholly consistent with and supportive of the President's program policy decisions.

The NRC press release announcing the report is also enclosed.

3. Copies of the Terms of Reference for the two new studies the Space Council is undertaking:
 - National Space Launch Strategy Review
 - Commercial Space Policy Implementation Strategy Review

Enclosures

THE WHITE HOUSE

Office of the Press Secretary

For Immediate Release

March 8, 1990

STATEMENT BY THE PRESS SECRETARY

On July 20, 1989, in a speech commemorating the 20th anniversary of the Apollo Moon landing, the President announced three major space policy objectives of the Administration: the completion of Space Station Freedom, a return to the Moon to stay, and a manned expedition to Mars. In that speech, he asked the Vice President to lead the National Space Council in developing policies and plans to accomplish these objectives.

The President announced today he has approved the first of a series of policy decisions for the longterm Space Exploration Initiative he announced on July 20. Acting upon the recommendation of the Vice President and the National Space Council, the President has approved a program that will give early focus to technology development and a search for new and innovative technical approaches to the Moon and Mars missions.

The policy consists of the following elements:

- o The Initiative will include both Lunar and Mars program elements.
- o The early program will focus on technology development with a search for new/innovative approaches and technologies.
- o The program will include investment in high leverage innovative technologies with potential to make a major impact on cost, schedule, and/or performance.
- o The program will take at least several years defining two or more significantly different human space exploration reference architectures, while developing and demonstrating technology broad enough to support all; selection of a baseline program architecture will occur after that time.
- o The program will perform mission, concept, and system analysis studies in parallel with technology development.
- o The program will include robotic science missions.
- o By spurring research and development in high technology fields, the space program will help promote American economic leadership.
- o The program will require the efforts of several agencies. NASA will be the principal implementing agency. The

Department of Defense and the Department of Energy will also have major roles in the conduct of technology development and concept definition. The National Space Council will coordinate the development of an implementation strategy for the Exploration Initiative by the three agencies. To facilitate coordination, the Department of Energy will be added as a formal member of the National Space Council.

#

Contact: Elizabeth Prestridge
395-6175

THE WHITE HOUSE
WASHINGTON

DATE: 02/16/90

NOTE FOR: THE VICE PRESIDENT

The President has

seen ☒

acted upon ☒

commented upon ☐

the attached; and it is forwarded to you for your:

information ☐

action ☒

James W. Cicconi
Assistant to the President
and Deputy to the Chief of Staff
(x-2702)

cc: The Chief of Staff
General Scowcroft
David Bates
Mark Albrecht ✓



THE PRESIDENT HAS SEEN

THE VICE PRESIDENT

WASHINGTON

February 13, 1990

1990 FEB 13 PM 3:46

ACTION

MEMORANDUM FOR THE PRESIDENT

FROM: THE VICE PRESIDENT

SUBJECT: SPACE COUNCIL RECOMMENDATIONS ON THE SPACE
EXPLORATION INITIATIVE PROGRAM

DD

Purpose

This memorandum forwards for your review the National Space Council recommendations regarding the Space Exploration Initiative program.

Background

In your speech last July 20 commemorating the 20th Anniversary of the Apollo 11 Moon landing you asked me to lead the National Space Council in determining what's necessary for our next round of space exploration.

Your budget submission to Congress for FY 1991 contains \$1.266 billion for the Space Exploration Initiative directed at the manned exploration of the Moon and Mars. These resources will be divided between investments in technology, new and better means to launch payloads into space, and unmanned scientific exploration of the Moon and Mars. The overarching goals of this program are to advance U.S. leadership in the exploration and use of space for scientific, technological, and economic purposes. In addition, your budget request includes \$2.627 billion to begin construction of Space Station Freedom.

Recommendation

The National Space Council recommends that you approve the following policy for the Space Exploration Initiative:

- o The Initiative will include both Lunar and Mars program elements.
- o The early program will focus on technology development with a search for new/innovative approaches and technology.
- o The program will include investment in high leverage/innovative technologies with potential to make a major impact on cost, schedule, and/or performance.

o The program will take at least several years defining two or more significantly different human space exploration reference architectures, while developing and demonstrating technology broad enough to support all; selection of a baseline program architecture will occur after that time.

o The program will perform mission, concept, and system analysis studies in parallel with technology development.

o The program will include robotic science missions.

o By spurring research and development in high technology fields, the space program will help promote American economic leadership.

o The program will require the efforts of several agencies. NASA will be the principal implementing agency. The Department of Defense and the Department of Energy will also have major roles in the conduct of technology development and concept definition. The National Space Council will coordinate the development of an implementation strategy for the Exploration Initiative by the three agencies. To facilitate coordination, the Department of Energy will be added as a formal member of the National Space Council.

* The Attachment provides expanded discussion of these proposed policy features.

Approve ✓

Approve as Amended 2-16-92

Disapprove

Attachment

Tab A Expanded Discussion of Proposed Policy

Attachment -- Expanded Discussion of Proposed Policy
Space Exploration Initiative

- o The initiative will include both Lunar and Mars program elements.
- o The early program will focus on technology development with a search for new/innovative approaches and technologies.

Spurred by the focus on technology development, the early program would provide ancillary benefits such as strengthening U.S. capabilities in key industries, stimulating science, engineering and mathematics education, and promoting excellence in science and engineering disciplines.

- o The program will include investment in high leverage innovative technologies with potential to make a major impact on cost, schedule, and/or performance.
- o The program will take at least several years defining two or more significantly different human space exploration reference architectures, while developing and demonstrating technology broad enough to support all; selection of a baseline program architecture will occur after that time.
- o The program will perform mission, concept, and system analysis studies in parallel with technology development.

The early stages of the program, lasting at least several years, would be devoted to laying a solid foundation for the Space Exploration Initiative. During this early phase, we would develop mission objectives, explore technology options, and analyze alternative mission scenarios and architectures. These studies would not involve formal system definition work.

The baseline architecture for human space exploration would not be selected for at least several years. In the ensuing period, a range of potential program architectures would be studied. These architectures would incorporate different technical approaches and performance capabilities (e.g., nuclear propulsion, heavy lift launch vehicles, lightweight/inflatable structures, etc.).

An integral part of the early stage of this program approach would be aggressive research to develop technology. Technology development looking at both evolutionary technologies and new/innovative approaches that could have significant effects on human exploration schedule, cost, risk, and/or performance, would be undertaken subject to the availability of funds for such efforts. Industry, universities, Federal laboratories, and other sources

outside NASA would be approached by NASA for ideas. An outside organization would be tasked to establish a review panel, composed of some of the nation's top scientists, engineers, and industry leaders, to evaluate promising alternatives. This approach, in addition to stimulating technology development, would allow the eventual architectural baseline to incorporate the benefits of all available aspects of technology innovation.

o **The program will include robotic science missions.**

The program would include robotic science missions as a critical element. The robotic science missions, in addition to significantly advancing scientific knowledge of the Moon and Mars, will obtain data needed to assist in the design and development of subsequent human exploration missions and systems and demonstrate technology and long-communications-time operations concepts.

Three specific robotic science missions have already been approved as part of the President's FY 1991 Budget. These three missions, undertaken for their intrinsic scientific value, also make essential contributions to the data base required prior to undertaking manned missions to the Moon and Mars. These are: a significant enhancement of the previously approved Mars Observer which is scheduled for a 1992 launch; and two new missions, Lunar Observer and Lifesats (a series of satellites for biological research). Lunar Observer is scheduled for a 1992 launch; and Lifesats beginning in 1994. These three missions will be necessary regardless of the architecture chosen for any manned mission. Other missions will be studied before making new start decisions.

o **By spurring research and development in high technology fields, the space program will help promote American economic leadership.**

The Space Council will review alternative approaches to implementing the Space Exploration Initiative in order to enhance U.S. economic competitiveness. In addition, early Moon-Mars Initiative planning will emphasize the identification of a range of technologies and services that could be offered by, or in conjunction with, the private sector. Within one year, the Space Council will make recommendations concerning private sector participation in the program.

o **The program will require the efforts of several agencies. NASA will be the principal implementing agency. The Department of Defense and the Department of Energy will also have major roles in the conduct of technology development and concept definition. The National Space Council will coordinate the development of an implementation strategy for the Exploration**

Initiative by the three agencies. To facilitate coordination, the Department of Energy will be added as a formal member of the National Space Council.

The Space Exploration Initiative will involve technical capabilities relevant to programs other than civil space activities. Government agencies outside NASA have considerable expertise in areas which could significantly lower the exploration program's cost, improve its performance, and bring the schedule forward. The President's 1991 budget request identifies DOD space launch vehicle technology efforts (the Advanced Launch System and the National Aerospace Plane) being done in concert with NASA and the SP-100 space nuclear power development program between DOD, DOE, and NASA as multi-agency portions of the exploration program. In addition to these efforts, both DOE and DOD have classified programs with considerable promise and relevance. The proposed policy would formalize this involvement and provide a vehicle for expanded multi-agency efforts.

NASA, DOD, and DOE have unique capabilities to develop and analyze mission concepts and to conduct technology development activities. By fully utilizing the expertise, technical capabilities, and perspectives of the three agencies, the government will ensure that a full range of ideas and options are considered and that the Space Exploration Initiative will be implemented expeditiously and efficiently.

March 7, 1990

TERMS OF REFERENCE

NATIONAL SPACE LAUNCH STRATEGY REVIEW

PURPOSE: To review implementation of the space launch provisions of United States National Space Policy and develop a comprehensive national space launch strategy for Space Council consideration.

BACKGROUND: The National Space Policy identifies access to space, sufficient to achieve all United States space goals as a key element of national space policy. It states that United States space transportation systems must provide a balanced, robust, and flexible capability with sufficient resiliency to allow continued operations despite failures in any single system. It further identifies the goals of United States space transportation policy as: (1) to achieve and maintain safe and reliable access to, transportation in, and return from, space; (2) to exploit the unique attributes of manned and unmanned launch and recovery systems; (3) to encourage to the maximum extent feasible, the development and use of United States private sector space transportation capabilities; and (4) to reduce the costs of space transportation and related services.

SCOPE: This strategy review will comprehensively address all aspects of United States civil, commercial and national security space launch activities and the facilities and infrastructure which supports them. It will be coordinated with a parallel National Space Council review of commercial space strategy.

METHODOLOGY: The review will be conducted in three phases. Phase 1 will focus on defining the current launch situation. It will:

- Describe current and planned launch capabilities (e.g. performance, capacity, adequacy of infrastructure support, resilience to launch failure, etc.)
- Identify space launch needs, separating: 1) firm requirements associated with continued operation of existing space programs and other funded programs, 2) projected needs for programs or missions which are under consideration but have not yet been approved / funded, 3) Commercial launch needs (as provided by the commercial space strategy review).

- Compare current and planned space launch capabilities with these space launch needs and identify mismatches, if any.
- Assess the extent to which space launch capabilities sized to provide assured access to space for all currently defined launch needs will result in a robust national infrastructure capable of providing affordable and available access to space. Determine if any additional capabilities should be provided in order to enable new, currently unplanned, applications and, if so, what capabilities and how should they be financed?

Phase 2 will identify and analyze alternative actions available to the USG to resolve mismatches and meet U.S. space launch objectives. These may include, but not be limited to:

- Additional policy guidance, if needed.
- Development and acquisition of new systems or infrastructure.
- Investments in research and technology including the government's role, if any, in development of technology for commercial application.
- Investments in advanced ("leapfrog") technologies which offer the potential of large improvements in cost, performance or reliability.
- Modifications to procedures which might reduce launch costs or increase launch capacity.

Phase 3 will assess various combinations of policy, procedure and investment actions, including, if appropriate, revisions to management structures or changes in the current assignment of space launch roles and missions, to meet U.S. space launch objectives. Results will be incorporated in comprehensive space launch strategy alternatives for Space Council consideration.

PROCESS: The review will be conducted under the guidance of the National Space Council's Policy Implementation Review Committee (PIRC), by an Ad Hoc interagency working group, chaired by a member of the Council staff. Sub-groups or task teams may be established, as required, by the working group chairman. The review will be coordinated with, and will support, a parallel National Space Council review of Commercial Space Strategy.

SCHEDULE: The review will be conducted in accordance with the following schedule:

March 1990, Begin review.

June 1990, Council review of phase 1

September 1990, Council review of phase 2

October 1990, Council review of phase 3

MARCH 7. 1990

TERMS OF REFERENCE
COMMERCIAL SPACE POLICY
IMPLEMENTATION STRATEGY REVIEW

PURPOSE:

To assess the status of the commercial space market, review the implementation of the commercial space provisions of U.S. National Space Policy and develop a comprehensive commercial space strategy for National Space Council consideration.

BACKGROUND:

In the National Space Policy, the overall commercial space goal is to encourage continuing U.S. private sector investment in space and related activities in accordance with the following principles: (1) The U.S. shall encourage and not preclude the commercial use and exploitation of space technologies for national economic benefit. These commercial activities must be consistent with national security interests, and international and domestic legal obligations; (2) the U.S. will, as a matter of policy, pursue its commercial space objectives without the use of direct Federal subsidies; and (3) the U.S. shall encourage other countries to engage in free and fair trade in commercial space goods and services.

The policy directive also states that the U.S. government: (1) shall not preclude or deter the continuing development of a separate non-government Commercial Space Sector; (2) shall not conduct activities with potential commercial applications that preclude or deter Commercial Space Sector activities except for national security or public safety reasons; (3) supervise and regulate commercial space sector activities only to the extent required by law, national security, international obligations and public safety; (4) shall purchase commercially available goods and services to the fullest extent feasible; (5) encourage, to the maximum extent feasible, the development and use of U.S. private sector space capabilities, including space transportation; and (6) encourage the development of commercial systems which image from space, competitive with or superior to, foreign operated civil or commercial systems.

The National Space Policy has implementing guidance on the several areas including, definition and utilization of commercially available goods and services, cooperative agreements

with the private sector that protect the commercial value of intellectual property, pricing of government-provided goods and services, access and reimbursement for use of government facilities, and identification or elimination of laws and regulations that unnecessarily impede commercial space activities.

ISSUES:

There are a broad range of key concerns associated with the emergence of the non-Governmental Commercial Space Sector. These concerns include, but are not limited to:

- o The nature and scope of international competition in commercial space and development of an appropriate response to foreign government assistance to their commercial space activities.
- o Free and fair trade in international commercial goods and services, particularly with regard to the entry of goods and services from non-market or centrally-controlled economies.
- o Interpretation of the policy definition of "commercial goods and services."
- o Government practices that inhibit the commercial development of space -- such as procurement and risk management.
- o Private sector role, investment, involvement, and risk sharing in agency programs such as Space Station, Mission to Planet Earth, and the Space Exploration Initiative, as well as in USG planning for future national space infrastructure and transportation needs.

SCOPE:

This strategy review is intended to assess the status of the commercial space market and develop a long-term comprehensive strategy to encourage continuing U.S. private sector investment in space and related activities consistent with the provisions of the National Space Policy. In cases where current implementation does not meet those objectives, alternative implementation strategies will be developed and evaluated for National Space Council consideration. This review will be coordinated with a parallel National Space Council review of National Space Launch Strategy.

METHODOLOGY:

The strategy review will be conducted in three phases.

Phase One - Characterize the Commercial Development of Space

- o Develop an operational definition of commercial space activities.
- o Characterize the markets for commercial space goods and services in terms of: size of markets, amount of private investment, current and emerging space activities, barriers to entry, interaction with Government, and competitive environment -- including the role of governments in supporting their respective space industries.
- o Describe the U.S. Government implementation of National Space Policy to facilitate the commercial development of space.
 - Agencies will identify and describe specific activities, including inter-sector coordination, that implement or are aimed at future implementation of the National Space Policy. Relevant programs include, but are not limited to -- research and development, regulatory, procurement practices, international trade agreements, risk management, use of Government facilities.
- o Identify mismatches between the commercial space provisions of the National Space Policy and agency implementation of those provisions. This assessment will include, but not be limited to review of the following:
 - o Agency implementation of free and fair trade policy objectives including the status of international consultations on launch services (PRC, Europe).
 - o Procurement and regulatory policy and practices, including commercial space transportation.
 - o Commercial access to government resources including transportation, facilities, intellectual property, research and development, and reimbursement.
 - o Private sector participation in agency programs and plans for the future.

Phase Two - Identify and analyze alternative actions available to the USG to resolve the identified mismatches and to facilitate commercial development of space.

Phase Three - Develop and compare various combinations of actions identified in Phase Two and provide comprehensive strategy alternatives for National Space Council consideration.

PROCESS:

The review will be conducted, under the guidance of the National Space Council's Policy Implementation Review Committee (PIRC), by an interagency working group, chaired by a member of the Council staff. Sub-groups or task teams may be established, as required, by the working group chairman. In conjunction with the working group, the chairman will determine the format of the various analyses generated by the working group's activities. The review will be coordinated with a parallel National Space Launch Strategy review.

SCHEDULE:

The review will be conducted in accordance with the following schedule:

March 1990, Review begins.

April 1990, Council review of Phase I

June 1990, Council review of Phase II

September 1990, Council review of Phase III

Date: March 1, 1990
Contact: Susan Turner-Lewis or Gail Porter,
(202) 334-2138

FOR IMMEDIATE RELEASE

PANEL IDENTIFIES MISSING ELEMENTS
IN PLANS FOR MOON/MARS MISSIONS

WASHINGTON -- While the National Aeronautics and Space Administration's (NASA) overall plans for a lunar base and expeditions to Mars appear "reasonable," a National Research Council committee today said* other strategies still must be studied and several major needs addressed. A new generation of vehicles to replace the space shuttle, the development of artificial gravity, and the potential use of nuclear propulsion and power are among the critical technologies that should be considered.

Stressing the preliminary nature of its review of plans by NASA and others, the committee said that any program for exploring the moon and Mars must "incorporate ideas from a variety of concepts, some that now exist and others that will arise in the future."

"This is an initial discussion to offer direction for helping the program get under way," said H. Guyford Stever, committee chairman and former presidential science adviser. "Certainly more intense scrutiny and evaluation of the options must take place before decisions are made regarding mission architecture."

Among crucial items that must be considered is the method of transportation

(OVER)

*The committee's report, Human Exploration of Space: A Review of NASA's 90-Day Study and Alternatives, is available from the Committee on Human Exploration of Space at the mailing address in the letterhead/telephone (202) 334-2855. Reporters may obtain copies from the Office of News and Public Information, also at the letterhead address.

to be used. Though NASA does not discuss eventual phaseout of the space shuttle in its "Report of the 90-Day Study on Human Exploration of the Moon and Mars," the committee stressed that the shuttle fleet will have to be replaced by a highly reliable, less labor-intensive system. "Continued access of humans to space will require that planning begin soon for a new transportation system that will first supplement and then assume the shuttle's role . . . sometime between 2000 and 2010," the committee said.

In addition, NASA should place even more emphasis than it now does on developing technology to ensure the well-being of astronauts. Intensified research, on the ground and in space, is critical for determining how low-gravity environments affect human performance and adaptability after long time spans, the committee said. Likewise, the development of artificial gravity should be included on the list of key research needs. Plans for building the nation's first space station, Freedom, may have to be supplemented or enhanced to conduct the needed research, the committee said.

NUCLEAR PROPULSION AND POWER

The NASA study mentions, but does not underscore, the need to develop safe nuclear power and propulsion for use in space. The committee, however, said nuclear power is "essential" for meeting the heavy demands for electricity on the moon and Mars. It described nuclear propulsion as a potentially important technology for reducing weight and travel time to Mars.

The 14-member panel was established in January at the behest of Vice President Quayle, chairman of the National Space Council, who is charged with making recommendations to President Bush regarding the best plan for sending humans to the moon and Mars. Bush announced his commitment to the project, known as the Human Exploration Initiative (HEI), last July on the 20th anniversary of the Apollo moon landing. The National Research Council committee examined the NASA study, a concept developed by the Lawrence Livermore National Laboratory called "The Great

(MORE)

Exploration," and several other strategies for implementing the HEI during a recent five-day meeting in Washington, D.C.

TARGETED DATES

The NASA plan would place humans on the moon in 2001 and on Mars by 2011, at the earliest. But the Research Council committee emphasized that these early dates depend on accelerating completion of Space Station Freedom, and that could result in higher risks and costs.

The Livermore Laboratory proposal, "self-described as 'reward- and risk-intensive'," suggests that the same objective could be achieved by the year 2000 at a cost of \$10 billion by using available technologies and less-expensive inflatable modules. The committee disagreed with that claim, however, saying "it underestimates the many practical and difficult engineering and operational challenges involved." The Livermore plan suggests possible use of lightweight inflatable structures made of a Kevlar-type material. Theoretically, those modules could be hauled into space in collapsed form, then inflated and outfitted for various uses. The proposal also depends heavily on "off-the-shelf" technology that might not perform well in space, on the moon and Mars, the committee noted.

A plethora of unknowns exists regarding the scope and the pace of the HEI regardless of the "mission architecture" decided upon, the committee said. Moreover, the project will entail new technologies that do not yet exist. For that reason, cost estimates are extremely difficult to ascertain, the committee concluded.

HEALTH AND SAFETY

Likewise, not much is known about the effects of extended space travel on the human body. "Significant unanswered scientific questions exist" concerning the body's ability to adjust to gravity following an extended period in a weightless environment, the report says. "It has not been demonstrated that after long duration spaceflight individuals can readjust rapidly to gravity without serious physiological consequences." Research should be undertaken to develop "artificial gravity" and

(OVER)

countermeasures -- a combination of special space suits, cardiovascular exercise, and medication -- to minimize "unacceptable risks to the crew."

In addition, the role robotics should play in minimizing human exposure to the extreme environment of space and in enhancing productivity must be more fully explored, the report says.

The president's mandate for building Space Station Freedom, as outlined in the NASA report, is a crucial first step, the committee said, "essential for conducting research on human performance" in a low-gravity environment. The National Space Policy calls for an operational space station in lower-Earth orbit by the mid-1990s.

The committee also said that instead of establishing a base on Mars itself, as proposed in the NASA study, for early missions consideration should be given to exploring the planet from a space station based in Mars orbit.

TRANSPORTATION NEEDS

In addition to replacing the space shuttle, a new generation of launch vehicles will be needed to lift massive equipment into lower-Earth orbit. The new system should incorporate all-liquid propellants to replace solid boosters, the committee said. Solids have distinct drawbacks: They cannot be tested before use and they pollute the atmosphere with chlorides. Since the Moon and Mars program will signal an increase in the number of launches, a new generation of liquid propellants should be developed to eliminate those shortcomings, the committee said.

Although the NASA study relies heavily on chemical propulsion for transporting astronauts, the committee said nuclear propulsion would slice travel time from Earth to Mars by one-third to one-half. "If safety concerns can be successfully addressed, and feasibility demonstrated, the committee believes that use of nuclear power and propulsion can meet many needs in the human exploration of space," the report notes.

While the technological uncertainties limit the ability to place a price

(MORE)

tag on the project, the cost of the Apollo program offers some insight, the committee said. During the peak spending year for Apollo, NASA's budget amounted to 0.8 percent of the Gross National Product. In comparison, today NASA's budget is equal to about 0.2 percent of GNP (or about \$12 billion a year). Increasing the budget by "a few tenths of 1 percent of annual GNP should be sufficient to achieve and sustain the goal of the Human Exploration Initiative," the committee said. In fact, the HEI probably could be undertaken for a percentage of GNP less than what was spent on Apollo because that was a "ground-breaking program that incurred substantial cost to build facilities and institutions."

An underlying issue is the need to garner long-term public support for "what could be an unprecedentedly long commitment to a national space goal." The report echoes a 1989 National Research Council white paper calling for a strong, stable space policy in the form of a basic program, and special projects -- Space Station Freedom and missions to the moon and Mars, for example -- to be funded separately.

MANAGEMENT CONSIDERATIONS

The success of the project in large part would depend on how well it is managed, the committee said. "Recent experience on programs such as Space Station Freedom has demonstrated the difficulties that result when a program's entire management team is consumed by phasing, rephasing, planning, replanning, rescoping, and descoping a program in ceaseless variations." Long-range objectives must be set and followed, and innovative uses of other federal agencies, "the private sector, universities and federally supported research centers" must be considered.

The potential exists, too, for collaboration on the project between the U.S. and international entities including the European Space Agency, Japan, Canada, and the U.S.S.R., the committee said. However, benefits and drawbacks to such an endeavor should be carefully weighed beforehand: cost-sharing and peaceful cooperation versus U.S. dependence on foreign countries for critical activities and

(OVER)

concern over broad-based technology transfer.

Serving with Stever on the committee were Robert H. Cannon Jr., Charles Lee Powell Professor and chairman, department of aeronautics and astronautics at Stanford University, Stanford, Calif.; Joseph G. Gavin, senior management consultant, Grumman Corp., Bethpage, N.Y.; Jack L. Kerrebrock, Fairchild Distinguished Scholar, California Institute of Technology, Pasadena, and R.C. Maclaurin Professor of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge; Louis J. Lanzerotti, distinguished member of the technical staff, physics division, AT&T Bell Laboratories, Murray Hill, N.J.; Elliott C. Levinthal, associate dean for research and professor of mechanical engineering, Stanford University, and director of the Stanford Institute for Manufacturing and Automation; James W. Mar, J.C. Hunsaker Professor of Aerospace Education, Massachusetts Institute of Technology; John H. McElroy, dean of engineering, University of Texas at Arlington; Duane T. McRuer, president and technical director, Systems Technology Inc., Hawthorne, Calif.; William J. Merrell Jr., president, Texas A&M University, Galveston; Robert H. Moser, vice president for medical affairs, The NutraSweet Co., Deerfield, Ill.; Eberhardt Rechtin, professor of engineering, University of Southern California, Los Angeles; Thomas P. Stafford, Lt. General, USAF (ret.), former astronaut during the Gemini and Apollo programs, and head, Defense Technologies Inc., Oklahoma City, Okla.; and Laurence R. Young, professor of aeronautics and astronautics, Massachusetts Institute of Technology. JoAnn Clayton served as study director.

#

stl: a,b,c,f,g,h,i,l,m

HUMAN EXPLORATION OF SPACE

*A Review of NASA's
90-Day Study and Alternatives*



HUMAN EXPLORATION OF SPACE

*A Review of NASA's
90-Day Study and Alternatives*

Committee on Human Exploration of Space
National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C. 1990

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Frank Press is president of the National Academy of Sciences.

The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Robert M. White is president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Samuel O. Thier is president of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Frank Press and Dr. Robert M. White are chairman and vice chairman, respectively, of the National Research Council.

This study was supported by Contract NASW-4003 between the National Academy of Sciences and the National Aeronautics and Space Administration.

Available from:

Committee on Human Exploration of Space
National Research Council
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In Memoriam

General Samuel C. Phillips, who had agreed to serve on the Committee on Human Exploration of Space and who had begun preparatory work for the study, died on January 31, 1990. He had a long and distinguished career that included directing the Apollo program from 1964 through the lunar landing in 1969, commanding the US Air Force Space and Missile Systems Organization, directing the National Security Agency, and heading the Air Force Systems Command. General Phillips later served as a Vice President for TRW. He performed many analyses of critical US space issues, and only recently was a valued member of a National Academy of Sciences/National Academy of Engineering study of US space policy. General Phillips' death is a great loss to the nation and to his colleagues who worked with him through the years.

Acknowledgments

The committee wishes to thank the many individuals from industry, academia, and federal agencies and laboratories who took the time either to meet with the committee or to make their views available in other ways. NASA Administrator Richard Truly, his associate administrators and staff, along with National Space Council Executive Secretary Mark Albrecht and his staff, were very frank and forthcoming with information concerning the President's human space exploration initiative.

In addition, the following individuals presented their ideas and technical concepts to the committee: Lowell Wood and his associates from the Lawrence Livermore National Laboratory, who briefed us on The Great Exploration; General Richard C. Henry of Brown & Root, who discussed the Workhorse Launch System; Maxwell W. Hunter, who made a presentation on the SSX, a single-stage-to-orbit launch system; Peter Wilhelm of the Naval Center for Space Technology, who explained the SEALAR concept, involving launching recoverable vehicles at sea; Michael D. Griffin, Deputy for Technology of the Strategic Defense Organization, who discussed project management techniques; and Lt. Colonel Roger Lenard, who described a nuclear propulsion concept. A full list of invited presenters and guests is contained in Appendix B.

Thanks are in order as well to the staffs of the National Research Council (NRC) Space Studies Board and the Aeronautics and Space Engineering Board for their help and cooperation in putting together the

study. Last, we would especially like to thank the study's Executive Director JoAnn Clayton for her thoughtful guidance at every stage and NRC Assistant Executive Officer for Special Projects Myron F. Uman for his wise counsel and constructive reviews of the draft report.

H. Guyford Stever, *Chairman*,
Committee on Human Exploration of Space

Summary

President George Bush on July 20, 1989, announced a US commitment for humans to return to the Moon and to journey to Mars; the Vice President in his capacity as Chairman of the National Space Council (NSC) was charged with making specific recommendations about how the President's initiative could best be achieved. The National Aeronautics and Space Administration (NASA) then prepared a document, based on earlier NASA analyses, to aid in the decision-making process. Subsequently, the Vice President requested that the National Research Council (NRC) assess the scope and content of the NASA document as well as alternative approaches and various technology issues. The Vice President presented the NRC with a challenging set of questions that resulted in this report.

In examining the *NASA Report of the 90-Day Study on Human Exploration of the Moon and Mars* and alternative concepts, the committee concluded that the appropriate framework in which to consider alternative approaches to meeting the President's initiative has at least four components. The committee's major findings and conclusions follow, presented in that framework.

MISSION CONCEPTS

Questions arise about the appropriate pace for the President's initiative; the scope of initial human exploration missions; and the level of long-term support that will be required for what could be an unprecedentedly long commitment to a national space goal. Development of policy,

advanced technologies, and mission concepts will probably be a continuing and iterative process. However, there is a need for guidance at an early date regarding the scope and pace of the early stages of the Human Exploration Initiative (HEI).

- As directed by the President, the space station is an integral first step in the HEI, but its present design may not meet all of the requirements for the HEI.

- The mission concepts in the NASA 90-Day Study prudently build on proven concepts and methodical research, development, and demonstration of new technology. The concepts are comprehensive and robust, implying relatively low risk.

- The Great Exploration, a concept developed by the Special Projects Office of the Lawrence Livermore National Laboratory, proposes to use available terrestrial equipment, accelerated administrative and procurement procedures, and a potentially feasible technology (inflatable modules) in an aggressive approach to reach Mars at the earliest possible time, but entails relatively high risk. The concept contains technical ideas that should be pursued, but the committee believes it underestimates the many practical and difficult engineering and operational challenges involved.

- It appears likely that the eventual choice of mission architecture will incorporate the ideas from a variety of concepts, some that now exist and others that will arise in the future. One concept, for example, would place the permanent human habitat in orbit, rather than on the surface of Mars. The variety of concepts should be regarded as a "menu" of opportunities.

HUMANS IN SPACE

Significant unanswered scientific questions exist concerning the feasibility of long-duration human spaceflight in a low-gravity environment. While it has been demonstrated that the human body adjusts remarkably well to the absence of gravity for short-duration flights, it has not been demonstrated that after long-duration spaceflight individuals can readjust rapidly to gravity without serious physiological consequences. The capability to send humans into space, maintain them in a physical condition that permits them to work productively, and return them to Earth in good health is central to the HEI.

- A program of scientific research on the effects of microgravity on human performance and welfare is critical for determining the mission architecture for the HEI.

- Development of technology for artificial gravity and countermeasures to mitigate zero-g exposure should proceed in parallel with studies of the physiological effects of microgravity.
- An emphasis on advanced human/machine systems can enhance the productivity of humans in space and increase their safety.

TECHNOLOGY DEVELOPMENT

Strategies are needed to develop and employ new technologies that will enable more rapid or cost-effective access to and habitation in space. Developing these strategies implies making trade-offs among alternative approaches. An important factor in these decisions is the level of human and technical risk that is acceptable. While major aerospace undertakings usually entail risks, recognizing them early in the planning stages of a major initiative may help identify choices that offer opportunities to manage the risks. A balanced technology development program with emphasis on critical long-term technologies can help to reduce risks and provide important options for the future.

Second to the need for scientific research and technology development to support humans in space is the need to advance national space transportation capabilities.

- A new generation of heavy lift launch vehicles is needed to transport massive cargoes to low Earth orbit (LEO).
- To transport humans to space, the nation must rely on the space shuttle for at least 10 years, and it is essential that the existing shuttle fleet be maintained in a fully operable condition. A new vehicle eventually will be required to transport humans and other precious cargo to LEO, emphasizing high reliability, robustness, and efficient ground operations.
- Nuclear rocket propulsion could make an important contribution to the HEI if it proves feasible and safe and can gain public acceptance.
- To meet the heavy demands for power on the Moon or Mars, nuclear electric power eventually will be essential.

SCIENCE GOALS

Another set of considerations concerns the expansion of knowledge. While the cardinal goals for the HEI may be related to leadership imperatives and to revitalizing the national research and development effort, important information can be gained about ourselves and our planet, about ongoing and past physical and biological processes, and about the history of the universe.

- Scientific research required to enable the initiative includes robotic precursor missions to learn more about the Moon and Mars as well as critical studies in the life sciences.
- Other research opportunities can be enabled by the HEI, for example, astronomical studies from a lunar base and geological studies of the Moon and Mars.
- Research that may become possible because of the HEI should be evaluated in the context of research strategies for the respective scientific disciplines, and with consideration of alternative ways of conducting the research. This analysis should be based on detailed scientific discussions and strategy development.
- Before defining scientific research for a lunar base, evaluations are needed on the effects of an inhabited lunar environment on scientific objectives and on instrumentation.

ADDITIONAL CONSIDERATIONS

The committee assumed that, independent of a program for human exploration of space, a vigorous base of civil space programs will exist, including astronomical research, solar and space physics, unmanned planetary exploration, and Earth remote sensing, supported in the near term by both expendable launch vehicles and by the space shuttle. In addition, technology will be developed, operational experience gained, and valuable scientific information obtained by the space programs of Europe, the USSR, and Japan, as well as by our own military space programs.

The climate for international cooperation is changing and is likely to continue to change. A detailed assessment is needed of the opportunities for international cooperation that may be available and the means to overcome technical and institutional barriers. It would be prudent to remain alert to future opportunities that may arise. At the same time, care must be taken that any enabling agreements are supported at the highest possible levels in the participating governments, with as much breadth as feasible, and that detailed technical agreements are not made final before all parties understand and agree on the requirements for the HEI or missions associated with it.

Finally, the nation is at a very early stage in the development of an HEI. None of the analyses to date—the NASA 90-Day Study, The Great Exploration, or, indeed, this report—should be regarded as providing anything other than a framework for further discussion, innovation, and debate. The HEI is an ambitious undertaking that requires development and implementation of new technology. Accurate cost estimates are only practical in circumstances where experience with the technology exists. Currently, the technologies and the HEI mission architectures are unknown.

While the nation has experience with estimating costs of some aspects of HEI, derived from experience with the costs of past space systems, at this time mission cost estimates should only be taken as suggesting the rough order of magnitude of the eventual costs.

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Introduction

BACKGROUND

On July 20, 1989, the President of the United States affirmed a national space policy that emphasized the expansion of human presence and activity beyond Earth orbit. His vision included completing Space Station Freedom, returning permanently to the Moon, and eventually sending humans to explore Mars. In response to the President's declaration, the National Aeronautics and Space Administration undertook a review of the main elements of such a program, characterized as the Human Exploration Initiative (HEI). The review, entitled the *Report of the 90-Day Study on Human Exploration of the Moon and Mars*, was based on feasibility studies that NASA had conducted in the past. The report contains five "reference approaches" that are intended as a data base for planning, or as a starting point for future discussions involving technical, budgetary, or scheduling options. The primary audience for the report was the National Space Council, headed by the Vice President of the United States.

Subsequently, the Vice President invited members of several scientific and industrial communities in the US to participate in considering the best ways to address the national HEI. On December 4, 1989, the Vice President wrote to the Chairman of the National Research Council (NRC) asking for a review of the scope and content of the NASA report including the questions of whether the "report addresses the widest possible range of technically credible approaches to meeting the President's exploration

goals," the reasonableness of NASA's technical assumptions, whether the report has overlooked possible innovative uses of existing technology or alternative ways to accomplish human space exploration, and whether the range of both desirable and enabling scientific objectives was appropriate. The committee was not asked to approve or endorse any aspect of the Human Exploration Initiative. (See Appendix A for the Vice President's request and the NRC response.)

PROCEDURE

In accordance with its practice and procedures, the NRC organized a committee of experts to prepare a report responsive to the request. The committee contains expertise ranging across many scientific and technical space disciplines. (Biographical data on committee members is found at the end of the report.) On January 4, 1990, several members, constituted as a steering committee, met in Boston to plan the undertaking. On January 17-21, 1990, the full committee and several invited technical and scientific advisors convened in Washington, D.C. The committee received a series of technical presentations on alternative mission scenarios and technical approaches from persons from private industry, universities, the Department of Defense, and national laboratories, and heard elaborations on the 90-Day Study and analyses from the NASA Administrator, several Associate Administrators, and other NASA representatives. In addition, the committee invited experts to brief them about four areas of space life sciences and also briefers to discuss the space nuclear power and propulsion programs run by NASA, the Department of Defense, and the Department of Energy. (A list of invited presenters and guests is contained in Appendix B.)

The committee considered a number of approaches to the HEI and its elements. These included the set of reference approaches addressed by NASA in its 90-Day Study and relevant programmatic information; an alternative approach called The Great Exploration, put forward by the Special Studies Program of the Lawrence Livermore National Laboratory; a concept that would utilize identical modules for a space station and the lunar and Mars missions; and several suggestions for improvement of launch and space propulsion capabilities. An extensive library was available to the committee, and key documents are listed in the bibliography.

Following two days of briefings on these matters, the committee spent two and a half days in discussion to begin preparation of the findings and conclusions in this document.

APPROACH

The committee regards the NASA 90-Day Study, currently available alternative mission scenarios, and the identified scientific and technical alternatives as starting points. It did not limit its deliberations to a review of the technical approaches in the NASA report and the alternative presentations, but extended its considerations to a number of interrelated nontechnical and institutional subjects, some of which are also addressed in the 90-Day Study.

The President's July 20 statement established a long-term objective of returning to the Moon and advancing humans to Mars. The President stated this policy in terms of an opportunity, not a race. (Excerpts from the July 20 statement and the subsequent National Space Policy document of November 2, 1989, are found in Appendix C.)

The pace at which the initiative should proceed, while clearly influenced by scientific and technical considerations, is inherently determined by social and political decision-making processes in which nontechnical constraints, such as the sustainable level of resource commitment and acceptable level of risk, are paramount. Within practical limits, technical analysts can develop alternative mission scenarios to achieve the stated goals under various sets of constraints, which provide ground rules for design. While scientists and engineers contribute to the policy debate, it is up to the political decision makers to establish the ground rules, which depend in turn on technical options.

To date the ground rules are unclear; as a consequence, technical analysts have presented mission scenarios based on differing assumptions. Many mission scenarios to establish bases on the Moon have been suggested, not only within NASA, but throughout the engineering and scientific communities of the US and the world. In its deliberations, the committee was exposed to only a few of these. Collectively, the committee is aware of many other possible scenarios, but lacked the time to examine them in detail. Some mission scenarios project a deliberate pace, extending current technology along foreseeable paths in order to minimize technical risk and maximize human safety. Other visions place higher emphasis on minimizing the time to get humans to Mars, incurring higher levels of technical and human risks. Clearly, there is need for guidance at an early date regarding the scope and pace of the early stages of the HEI.

In its reviews of alternative mission architectures and the underlying scientific and technical challenges, the committee also recognized a number of other issues inherent to achieving the President's goal. One was the challenge of educating, recruiting, training, and maintaining a technically competent work force. Another was the requirement for an appropriate

industrial infrastructure to carry out the work. Still another was the managerial and administrative challenge of mounting a project of this nature, one that will certainly take many years to accomplish and presumably will result in a sustained program supporting the presence of humans in space.

I

Alternative Mission Concepts

The Committee on Human Exploration of Space examined NASA's approaches to the HEI and a number of alternatives. However, a wide range of possibilities for program architectures and mission configurations exists that is yet to be examined in detail. The scope of early HEI missions can be defined, but, given the scientific and engineering unknowns, it is too early in the process to focus upon a single, final plan for a permanent return to the Moon and voyages to Mars. The need to bring innovative ideas to the planning process is widely recognized.

THE SPACE STATION AS A FIRST STEP

The President's policy incorporates Space Station Freedom (SSF) as the first step to achieving the ultimate goals of Moon settlement and Mars exploration. Although it is technically feasible to go to the Moon and Mars without the intermediate step of establishing a permanent station in low Earth orbit (LEO), most of the mission architectures under consideration employ a station for assembly of vehicles for travel beyond Earth, for storing fuel and supplies, and as a human transfer facility. In the near term, a facility in LEO is essential for conducting research on human performance and well-being in zero or fractional gravity as well as long-term confinement in zero gravity. It also can serve as a testbed for the life support system that eventually will be needed on the Moon and Mars, and can house experiments with artificial gravity, should that become a requirement for the journey to Mars.

Thus, the first major step to be taken in human space exploration is establishment of a station in LEO. The current station could meet some, but not all, of the requirements of the HEI. Proceeding with the HEI, therefore, would require continued development of the station to meet the demands of the initiative, including the conduct of life science research and use of the station as a spaceport. In the long term, the compatibility of the many functions to be performed on the station may be a serious question.

A more precise interpretation of the goals surrounding the return to the Moon and the advance to Mars, as defined by the social and political decision-making process, will help to determine the nature, magnitude, and pace of the lunar and Mars ventures. The question even arises whether an additional station, complementary to the first and designed as a transportation node, will eventually become necessary to accommodate the later, more demanding missions.

THE NASA REPORT OF THE 90-DAY STUDY ON HUMAN EXPLORATION OF THE MOON AND MARS

The NASA Report of the 90-Day Study provided descriptions of five reference approaches:

Approach A is formulated to establish human presence on the Moon in 2001, and the Moon is used as a learning center to develop the capability to move on to Mars. An initial nuclear power unit and lunar oxygen production demonstration hardware are added in 2003 to reduce lunar logistics requirements. Research is planned in geologic and geophysics exploration, geophysical and particle physics, and astronomy, as well as in the life sciences. The first Mars expedition is a 30-day stay on the surface, followed by a 600-day visit beginning in 2018, during which many scientific experiments are foreseen. This scenario involves advancing completion of SSF to 1997, requiring a heavy lift launch vehicle.

Approach B is basically the same as Approach A, except that it advances the first human Mars landing to 2011 and limits the degree to which lunar experience could affect the design of the Mars transportation and surface systems. It delays lunar science activities, but advances those on Mars.

Approach C is akin to Approach A, except it advances to 2005 the date by which lunar oxygen is available, requiring earlier development of nuclear power system capabilities. By accelerating lunar activities, the knowledge learned can be applied to Mars missions.

Approach D is also based on Approach A, except that all milestones are delayed two to three years, with a return to the Moon in 2004. Approach D does not require accelerating SSF and permits incorporation of new technology developments in plans for Mars excursions.

Approach E envisions a scaled-down, human-tended lunar base, and does not require that SSF be advanced in time. It includes a 600-day Mars simulation activity on the Moon. A lunar outpost is established in 2004, and three human expeditions to different locations on Mars begin in 2016, preceeding establishment of a permanent base.

The reference approaches in the NASA 90-Day Study are largely variations on a theme and have certain common features: They depend on heavy lift vehicles to LEO and on SSF for assembly in LEO and as a transportation node. They employ unmanned robotic precursor missions, reusable transfer vehicles to lunar and Martian orbits, and excursion vehicles at surface bases. Each features sequential Moon and Mars programs, assumes zero gravity in transit to Mars and requires a decade or more of research on adaptability of humans to low or zero gravity, depends on aerobraking (using atmospheric drag to slow a vehicle for capture in the planetary gravity field), and requires new chemical propulsion engines using cryogenic fuels. Proceeding from initial habitats to constructible bases, these reference approaches all provide an extensive, reusable orbital transfer capability and infrastructure designed for permanent occupancy of the Moon and Mars.

The approaches described in the NASA study are relatively low in risks, in that each would proceed in methodical steps after earlier steps have been proven and after scientific and engineering questions inherent in the architecture (e.g., nuclear propulsion, aerobraking, Mars surface habitability) are answered. The study recognizes the need for substantial advances in technologies such as those relating to the life sciences and nuclear power and propulsion. The committee believes the reference missions provide a useful background of possible mission configurations against which new ideas and concepts can be compared, and against which various cost and schedule scenarios can be analyzed.

The architectures of the reference approaches, however, were built upon the presumed objective of returning to the Moon permanently and establishing bases on the surface of Mars. Therefore, the reference missions do not provide explicitly for an option that may entail less risk: a habitable station in orbit around Mars from which exploration initially could be conducted by telerobotics and later by human excursions to the surface. Considerable energy is required to transfer mass to Mars orbit from the surface, so it would be prudent to minimize the need for such transfer. In this context, it appears that a station in Mars orbit requires a less demanding infrastructure than a surface base and might serve a useful purpose in the early stages of human space exploration.

An important aspect of the NASA Mars reference approaches is the reliance on aerobraking, a technology that has not yet been demonstrated

in the dilute Martian atmosphere. An aerobraking vehicle will require large surfaces, new materials, and precise controls to avoid descending too rapidly or deflecting from the atmosphere back into space. The final decision regarding aerobraking should await technology demonstration and further knowledge about the Martian atmosphere, as well as information regarding the weight trade-offs between successful aerobraking materials and fuel for propulsive braking, especially were nuclear propulsion to be available. Aerobraking has the potential for reducing the initial mass of a spacecraft by 20 to 50 percent, however, and demonstrations are needed to bring this technology to fruition.

Last, in these reference scenarios, extensive extravehicular activity (EVA) is implied for space construction and assembly. Human experience in space suggests that less EVA means safer missions, owing to the limited maneuverability and flexibility of astronauts in currently available space suits. Emphasis on teleoperations or more synergistic human/machine interactions can provide substitutes for extensive EVA. But to facilitate a wide range of human activities in space, it seems desirable to develop an improved space suit for necessary EVA tasks.

THE GREAT EXPLORATION

The most characteristic features of The Great Exploration concept are its success-oriented pace, the estimated low total costs projected by its proponents (permanent bases on the Moon and Mars by the year 2000 at an estimated cost of \$10 billion to the launch of the Mars excursion vehicle), and the use of essentially identical, preassembled, inflatable structures for an Earth-orbiting space station, for propellant storage, and for structures for the Moon and Mars. The technology of space-based inflatables has been studied extensively, but has not been demonstrated in space. It also appears in the NASA study, in less critical applications. Clearly, prior to commitment to the use of such structures, there would be a need for advanced development and demonstration of space-based inflatables and of specific techniques for incorporating the necessary expandable hardware and fixtures in such structures. The potential advantage of inflatables is the reduced requirement for lifting mass to LEO, perhaps even reducing the requirements for a new heavy lift launch vehicle. However, if preassembled inflatable modules prove not to be useful for one or more of the applications envisioned in this mission architecture, modules of traditional, rigid construction would have to be substituted, presumably with considerable effect on the mission concept.

A number of critiques have been performed on The Great Exploration concept and its proponents have prepared responses. The committee's judgments have benefitted from this exchange of information and analyses.

However, it might be noted that the projected economies of time and cost proposed for The Great Exploration depend, in part, on using off-the-shelf technologies and "standard terrestrial machinery and equipment." The committee is not convinced that off-the-shelf, terrestrial technology will perform as required in the environment of space, the Moon, and Mars, nor that the technology meets requirements for reliability that should govern human-rated space systems. For example, the development of machines and apparatuses and their operation must take into consideration the adhesive and abrasive nature of the lunar soil, which is well known from earlier lunar landings. Further, The Great Exploration proposes no robotic precursor missions to learn more about the environments of the Moon or Mars or to identify safe or scientifically interesting landing sites. The committee believes The Great Exploration underestimates the many engineering and operational challenges involved in bringing its technical concepts to practical realization.

The Great Exploration strategies are self-described as intentionally "maximally time-compressed" and "reward- and risk-intensive" to achieve the ultimate goals as quickly as possible, on the premise that "there has never been a successful 25-30 year Federal technology program." Special priority procurement processes and waivers that are not otherwise available in unclassified civilian programs are required in order to meet the demanding schedule. Such procedures may not be acceptable in an open project, especially if there are international partners.

Nevertheless, the committee believes there may be technologies in this alternative to the NASA approaches that should be further investigated, for example, the use of space-based inflatables for at least some of the required functions and modules.

OTHER ARCHITECTURES FOR THE HUMAN EXPLORATION INITIATIVE

Many other approaches exist for accomplishing the HEI. A concept was presented that featured advanced bases on the lunar surface and in Mars orbit essentially identical to SSF core modules. Modules, assembled on SSF as complete bases, would be mated with expendable propulsion systems to be launched intact and unmanned from LEO. The concept relies on the existing space shuttle for transport to orbit of relatively lightweight, valuable cargo and personnel and on a heavy lift launch vehicle for fuel and major unit (modules, nodes, spacecraft) transport. Mars orbit is selected as a preferred base from which to explore the planet, in the belief that it would be a more predictable and controllable environment than one of the Martian moons, and less dangerous than the planet's surface. The principal obstacle to going to the surface is that the space station

replica would not survive Mars atmospheric entry. Separate vehicles, also chemically propelled, are required for rapid transport of personnel.

In this concept the similarity of the space station, lunar, and Mars modules implies less development time and cost and indicates that Mars might be reached sooner for early exploration than if the Mars flights had to await technology validation by aerobraking research and development and nuclear propulsion demonstrations. The committee did not study this concept in great detail, but it appears that the principal unknown in this scenario concerns the stability of such modules in transit.

Among other early architectures that might be considered are the NASA baseline concept, with the initial Mars base in orbit rather than on the surface and the NASA baseline with separate cargo and crew transport systems, the latter with high-speed, staged chemical propulsion and even Earth launch of lunar and Mars missions. The committee is convinced that other alternatives will arise as concept development proceeds. The report of the National Commission on Space, *Pioneering the Space Frontier*, for example, contains stimulating discussions of future approaches to human exploration of space.

From the committee's brief exploration of these alternative concepts, it appears likely that the eventual choice of mission architecture will incorporate ideas from a variety of concepts, some that now exist and possibly some new ones. While the scenarios thus far described vary substantially in schedules, technologies, and in the need for research and development, all would benefit from advances in space transportation and in technologies critical to the support of humans in space. The committee found imaginative and worthwhile components in all of the presentations, and, at the same time, recognizes the value, at this time, of encouraging the search for new ideas.

II

Space Transportation: Launch Systems, Propulsion, and Power

The committee concurs with NASA's view and the general consensus that robust and reliable transport to LEO and beyond is essential to the success of HEI. Further, it believes that the currently available launch systems and their derivatives will not meet these criteria in the future. Improved capabilities are required for transport of humans and high-value cargo to and from LEO; transport of large unmanned components, propellants, and expendables to LEO; and orbital transfer to the Moon and Mars.

For reasons of cost and reliability, the transport of humans and other precious cargo will require a different launch system than those for the transport of more ordinary or bulk cargo. Because operations of the space shuttle will continue to be labor-intensive and expensive, because the system is not robust, and because the system probably will reach the end of its useful life sometime between 2000 and 2010, the committee believes that a successor to the shuttle eventually will be necessary for human transport to orbit. For at least the next 10 years, however, the nation will necessarily rely upon the shuttle for this role, and it is essential that the existing shuttle fleet be maintained in a fully operable state. As indicated in the NRC report, *Post Challenger Assessment of Space Shuttle Flight Rates and Utilization*, at least one additional replacement orbiter is likely to be required every 5 to 10 years to offset inevitable attrition of the present fleet. But orbiter replacements should not impede the emergence of a new capability for launch to LEO. Eventually, a plan for a graceful phasing out of the shuttle system should be prepared.

An important aspect of reducing costs, when considering the design of new launch systems, should be the efficiency of activities on the ground that are required to prepare vehicles and payloads for launch.

HUMAN TRANSPORTATION TO AND FROM ORBIT

The space shuttle system now appears to be operating satisfactorily, and there is reason to believe that with continued scrupulous adherence to proper manufacturing, maintenance, and operating procedures, it can continue to do so. It does, however, have a limited design life, like any high-performance system. It requires continuing refurbishment and in due course it will require major replenishment, or it will have to be supplanted. Continued access of humans to space will require that planning begin soon for a new human transportation system that will first supplement and then assume the shuttle's role in human transport to and from orbit, sometime between 2000 and 2010. The best available technologies should be used to produce a system that is robust, highly reliable, reasonably cost-effective, and that has minimum requirements for ground support and preparation for launch.

At present, the most likely configuration of the required system is a two-stage rocket powered vehicle, with a fly-back first stage, an orbiter with substantial cross range capability, and a thermal protection system or hot structure that allows reuse without major refurbishment. It may be that some of the technologies being developed in the National Aerospace Plane Program (NASP) will find application in this system.

UNMANNED LAUNCH SYSTEMS

In light of the evident requirements for lifting mass to LEO, a modern launch system with heavy lift capability will be essential. It does not exist in this country at this time. Therefore, a family of launch systems based perhaps on the interagency Advanced Launch System (ALS) or similar technologies should be defined and committed to development. The design of these systems, although not requiring a safety rating for humans, should still emphasize reliability and robustness over performance, as measured, for example, by the ratio of payload weight to gross weight. The level of reusability should be selected similarly to optimize the reliability and robustness of the systems and to minimize cost on the basis of realistic utilization rates. More reliable technologies can be used, at a given overall cost, if some of the critical components are recovered. It is the committee's view that if these criteria are met, substantial improvements in launch cost will accrue, relative to those for current systems.

The family of launch systems envisioned is likely to accommodate the

upper range of payload masses projected by the Department of Defense, as well as the heavy lift requirements of the HEI. This can be done by clustering modular liquid propulsion systems with staging appropriate to the particular launch requirement. Key features of the required new launch systems will be the use of modern materials and technologies. The engines probably will operate at chamber pressures below those of the space shuttle main engine and will be manufactured using advanced technologies, such as precision casting, which lower costs while improving quality. Guidance and control will take advantage of modern electronic technology to provide fault tolerance and largely eliminate single point failures. Even with these improvements, it will be desirable to configure the vehicles so that missions can be completed after loss of one engine early in a launch. With the higher performance that will be available, such robustness should be affordable.

The committee favors this approach for three reasons: First, if developed to the criteria outlined, such liquid bipropellant systems will have a higher level of reliability than do the solid boosters utilized on the shuttle. The engines can be test fired prior to launch, an engine-out capability is feasible, and engine shutdown in flight is possible if a fault is detected. Second, pollution of the atmosphere by chlorides, as occurs with solid propellants, would be eliminated. This is likely to become an increasingly serious issue as launch rates rise in the buildup of the HEI. Finally, the committee believes liquid bipropellant systems have the potential for significantly lower recurring costs compared to solids. Thus, for the long term, the committee anticipates reliance on liquid rockets.

There are several alternatives to the above strategy. One considered by the committee is a flexible family of launchers that would use existing fully-developed solid propellant motors in clustered arrangements, providing up to four stages and a wide range of payloads to LEO or to higher orbits. Such launchers are certainly feasible. Their development costs would be lower than those of the ALS-class systems discussed above, and their recurring costs would probably be lower than the Titan, shuttle, or Shuttle-C. The committee has three concerns about this concept: First, with a large number of solid motors, this system is not likely to be as reliable as those using liquid rocket technology. Second, the recurring costs are likely to be substantially higher than for an all-liquid system, and, finally, the solid upper stages would present environmental problems with injection of chlorides at very high altitudes.

The committee notes, however, that the universal launch system complex being designed for this family of launchers, based on oil platform technology, has very attractive features such as modular construction of assembly buildings and a launch platform that can be elevated. An elevatable launch platform avoids the construction of flame ducts and can serve a variety of launch vehicles. These should be considered carefully if a new

launch complex is needed. This concept could be applicable to manned or unmanned systems and could reduce costs for the entire launch complex.

Another alternative is single-stage-to-orbit rocket launch systems, which have been proposed many times. This option has been raised again in the present context in a configuration that conceptually would offer engine-out capability, a safe abort at any point in the launch, and full recoverability. The committee's brief review of this concept has led to the conclusion that it is founded on unrealizable assumptions regarding structural weight and propulsion system weight. Dramatic advances in single-stage structural technologies and in materials, even beyond those anticipated in current programs such as NASP, would be required to make this a viable concept.

A sea-launched, two-stage, fully recoverable system with pressure-fed engines has also been suggested, with the projection that the components could be reused up to 25 times. In any launch system, optimistic reuse projections can lead to attractive, but unrealistic, estimates of costs, and in the committee's judgment, such extensive reuse is improbable due to the effects of the marine environment. Ocean operations can pose more of a problem than an aid. Very large pressure-fed systems are also difficult to deal with and require very large nozzles. Further, this concept currently lacks a credible plan for recovery of the second stage, which would reach full orbital speed.

NUCLEAR THERMAL PROPULSION

Although the reference approaches in the NASA 90-Day Study rely on chemical propulsion, NASA has included nuclear thermal propulsion as an option to be considered for orbital transfer to Mars. Several possibilities have been mentioned within this general class of systems, all of which offer higher specific impulse than chemical rockets and employ hydrogen as the propellant.

The alternative nuclear propulsion technologies differ in the temperature to which the hydrogen is heated by the fissioning nuclear fuel; the pressure level in the thrust chamber (which along with the temperature determines the extent of dissociation of the hydrogen to atomic form); and the power density assumed to be achievable in the reactor. The temperature and pressure determine the specific impulse, while the power density largely determines the thrust-to-weight ratio of the propulsion system.

The baseline capability is taken to be the NERVA class technology, the technical feasibility of which was demonstrated in the late 1960s. In the NERVA program, a reactor was tested on the ground for periods longer than required for operation, at power densities that would yield thrust-to-weight ratios on the order of five, and at temperatures giving

specific impulse as high as 850 seconds. This technology is available for full-scale development. It should be evaluated for injection to Mars in competition with hydrogen-oxygen chemical systems. The higher specific impulse of the nuclear rocket results in a smaller propellant expenditure for a given total impulse, but the propulsion system weight is higher, so that its attractiveness depends on the velocity change needed, and whether the system is reused. A major advantage of nuclear propulsion is its ability to enable transfer between Earth and Mars in one-half to one-third the time required with single-stage chemical propulsion systems. This advantage could be critical, pending the outcome of research on human performance in space for long periods. The use of nuclear technology in space faces formidable barriers of public acceptance, however, especially if employed in Earth orbit. Therefore, issues of safety are paramount in research and development.

An advanced reactor design has been partially evaluated experimentally that offers much higher power densities, hence much higher thrust-to-weight ratios, than the NERVA class technology. If proven feasible, this class of technology will make the nuclear rocket more attractive relative to chemical propellants. The risk involved in this technology development appear very high at present, but the committee urges a feasibility test be carried out to determine what thrust-to-weight ratio is practically achievable. It also recommends that the potential of the technology be reviewed by a senior group experienced in nuclear rocket technology.

The 90-Day Study mentions gaseous-core nuclear rockets as offering much higher specific impulse levels. A number of gaseous-core reactor concepts were carefully evaluated in the years between 1959 and 1970, but none was found to be technically feasible. Unless a new idea has appeared, which is always a possibility, the committee believes the gaseous-core nuclear rocket technology is too speculative at this time and should be dismissed as a possibility.

If careful systems studies, using thrust-to-weight ratios and specific impulse known to be feasible, show a significant advantage for nuclear rockets in trip time or in weight to orbit, an in-space demonstration of this technology should be done as soon as possible—taking into account requirements for crew, ground personnel, and public safety covering all phases of launch and flight, including mission abort. It will not be feasible to select the nuclear rocket as a baseline in a system architecture until such a demonstration has been conducted.

NUCLEAR ELECTRIC POWER

The committee believes that nuclear power eventually will be essential

for lunar and Mars bases. The NASA reference approaches incorporate nuclear power; The Great Exploration does not.

At present, the only active technology program applicable to this need is the SP-100 thermoelectric space reactor, which has been pursued under a tri-agency program for several years. SP-100 was initiated in the absence of a definite mission requirement as a general purpose space power source. This program should be redefined in light of the requirements of the HEI and committed to development; nuclear thermionic research should continue to be pursued as well.

Consideration should be given to demonstration of the nuclear electric power system as the power source for an electric propulsion system, which may have application to science missions with large launch velocity requirements. (In fact, a number of outer planet missions have been suggested, including a Jovian system grand tour, that will require such advanced power sources.) Here, as with the nuclear rocket, considerations of safety must be incorporated into research, development, and demonstrations and factored into assessments of overall systems performance. The nuclear electric system might be demonstrated within these constraints by a mission in which the system is launched to a high orbit, say 600 miles, before it is operated. The orbit could then be raised by nuclear-electric propulsion to geosynchronous orbit or beyond.

If safety concerns can be successfully addressed, and feasibility demonstrated, the committee believes that use of nuclear power and propulsion can meet many needs in the human exploration of space.

III

Other Critical Technologies for the Human Exploration Initiative

Ongoing development of certain specific technologies is essential to the HEI and offers potentially high payoffs in capabilities and long-term cost savings. The committee assumes that HEI technology development will complement rather than displace the NASA program of basic research and technology development in such areas as materials and structures, sensors, air-breathing engines, and data processing.

THE NASA 90-DAY STUDY

The Technology Assessment section (Chapter 8) of the 90-Day Study lists seven technologies (regenerative life support systems, aerobraking, advanced space engine, surface nuclear power, in-situ resource utilization, radiation protection, and nuclear thermal rocket propulsion). It continues with "other technology needs, briefly sketched" under titles like "humans in space." Although the NASA Figure 8-1 envisions focused research that does not continue after five years, ongoing advanced technology research will clearly be characteristic of the HEI for many years.

The committee agrees that these technologies are important, but believes that strategies for development of technologies should take account of the lead times required and incorporate priorities according to whether the technologies are essential to the HEI, or serve to enhance capabilities. For example, provision of radiation protection, life support, and crew safety are survival imperatives for all human space-based modes, and must be addressed as major architectural considerations. Research on artificial

gravity should be added to this list. On the other hand, aerobraking, in-situ resource utilization, and nuclear thermal rocket propulsion technologies may offer significant advantages in certain mission scenarios, but are not essential for human missions in general.

There are other specific new technologies, not in NASA's list of seven critical technologies, that can profoundly simplify and enhance operations in every mission scenario. Two clear examples are (1) advanced human/machine systems for tasks in space, in order to improve the efficiency of humans, and (2) far more capable information management systems for mission decision making. While the 90-Day Study recognizes advances in information systems and automation and robotics as being important to the success of the HEI, the emphasis should be on technologies that go one step farther, to greatly advanced computer-aided mechanical extensions of human performance, i.e., human/machine systems.

ARTIFICIAL GRAVITY

Artificial gravity was not included in the NASA list of critical technologies. With the current state of knowledge, a multiyear exposure to weightlessness, even with on-board exercise and countermeasures and an intermediate stay on the surface of Mars, presents unacceptable risks to the crew. Adaptation to microgravity makes return to a gravity environment dangerous and renders human performance on the surface of Mars problematical. The questions of whether artificial gravity will be required and, if so, how it will be provided are critical. The nation has no strategy for research to determine the need for or provide artificial gravity.

Several alternative approaches to addressing the problem can be considered. In one, an early commitment could be made to provide artificial gravity in the transfer vehicle to Mars. This option is not included in the 90-Day Study, but has been reviewed by NASA in the past and found to increase the mass of a Mars transit vehicle by no more than 20 percent, under the most conservative assumptions.

Another alternative is to determine the requirements for artificial gravity by testing humans in a variable-gravity research facility in LEO. Such a facility should permit research on human physiological deconditioning and countermeasures, including different artificial gravity radii and rotation rates, in order to determine the optimal combination of gravity levels and exposure times. Because of time considerations in human deconditioning phenomena, an operational research period lasting two to six years must be anticipated before definitive answers about artificial gravity can be expected.

Short of undertaking long-duration research on human performance in space, any research strategy for minimizing human risk of irreversible or incapacitating deconditioning should make maximum use of ground and

space station facilities for relevant life science research. Ground bed-rest studies and incremental duration exposure of subjects in a space station must be integrated with animal research in orbit, including use of the SSF on-board centrifuge. In parallel with these tests, the effectiveness of several candidate countermeasures to deconditioning should be evaluated in controlled experiments. If the deconditioning is unacceptable and the simpler countermeasures are ineffective or onerous, full-scale space-based artificial gravity evaluation and facility development become imperative.

Another alternative approach, which is less thorough than the use of a variable-gravity research facility but which could be carried out in parallel with a lunar base development, is an investigation of the effectiveness of lunar gravity as a long-term countermeasure. This approach would provide deconditioning data at three levels: 0, 1/6, and 1 g. It would not, however, help with the question of gravity gradient or contribute to any of the engineering issues regarding a spinning spacecraft for Mars transit. This approach is the most limited and time consuming. It also carries with it the risk of negative results that would require the eventual, but delayed, artificial gravity investigations described above.

ADVANCED HUMAN/MACHINE SYSTEMS

Mechanical and computer-aided extensions of human (astronaut) managers can provide enhanced efficiency in inspection, assembly, maintenance, repair, and exploration tasks. The most powerful approaches to human exploration will integrate humans with machine systems to accomplish more than either can do alone. These approaches can range from low-level, hand-in-glove teleoperation, through higher-level object-motion commands, to planned task commands by a distant astronaut. Application of the many automation and robotic systems needed to integrate humans and machines can range from some of the early systems developed for space station management and operations, to precursor nonhuman missions, to advanced synergistic systems of humans and machines operating on another planet.

Advanced human/machine systems are not merely an enabling technology, but a requirement for practical HEI operations. Technical advances can extend profoundly the human role as master of highly flexible human surrogates, but obtaining such potential benefits will require more than complex robotics and automation. NASA presentations based on the 90-Day Study implicitly recognize this by grouping operations in functional categories. Systems that integrate automation and robotics with humans permeate the arenas of vehicle maneuvering; vehicle servicing in space; in-space and surface assembly and construction; planetary rovers; surface operations; extravehicular activity and exploration; sample acquisition, analysis, and preservation; and scientific probes and penetrators. Reduction of

IV

Space Science and the Human Exploration Initiative

The NASA 90-Day Study reflects an initial attempt to identify the scientific components of the HEI. It identifies five themes around which the science elements of the initiative are developed and states that the "fundamental scientific themes . . . can be uniquely addressed by the Human Exploration Initiative." Several specific examples are presented of scientific objectives in precursor flights to the Moon and Mars. The 90-Day Study provides evidence of NASA's intention that scientific research be an integral part of the HEI. Nevertheless, it is clear that much of the research in the NASA scientific themes does not require an HEI.

It is useful to divide the scientific research issues into three broad categories. First, there are scientific studies to enable the initiative—those that must be done before humans can travel to Mars, perform useful tasks, and return safely. Second are studies and experiments that can only be conducted as a result of the envisioned long-term human missions. Third are studies that may be undertaken in association with those missions, but could be carried out otherwise if necessary. Any scientific knowledge that might be obtained in association with long-term human missions should be evaluated in competition with other modes of gathering the same information (e.g., human-tended, telerobotics) and with other scientific research goals. This competitive category of scientific research should not be used as, nor considered to be, the primary justification for a national commitment to human exploration of space.

SCIENTIFIC KNOWLEDGE AS A PREREQUISITE FOR HUMAN EXPLORATION

The most important issues of prerequisite scientific knowledge concern those matters that are critical to human health and safety, including microgravity effects on physiologic functions, the effects of radiation, controlled environment life support systems, site-selection and contamination issues, and the psycho-social aspects of prolonged exposure in a confined habitat.

In every pioneering effort there are risks, known and unknown, that are intrinsic to the endeavor. Those responsible must make the fullest efforts to reduce the known risks to reasonable levels and make clear the levels of risk that remain. Potential hazards must be explored and countermeasures devised to reduce risk. Research is required to explore the range of risk and to devise reasonable countermeasures.

Life Sciences

Microgravity Issues

Data are incomplete regarding the effects of the microgravity environment on human physiology (including the cardiovascular, vestibular, and immune systems); more research is also necessary on adequate countermeasures. As noted in the NRC *Strategy for Space Biology and Medical Science*, "If this country is committed to the future of humans in space, particularly for long periods of time, it is essential that the large number of uncertainties about the effects of microgravity on humans and other living organisms be recognized and vigorously addressed." The 90-Day Study envisions research to develop countermeasures to the effects of very low gravity and to promote the basis for designing artificial gravity environments, if required. A rigorous research program would be based largely on facilities available in an Earth-orbiting station, designed to gain an understanding of the effects of a microgravity environment on humans. As NASA indicates, the results of this research will have significant implications for mission architectures and mission time profiles.

Radiation Issues

Radiation from solar and galactic sources poses serious potential hazards to human health. Predictions of solar flares and of solar flare particles remain uncertain, but successful predictions are not prerequisites to human spaceflight, if adequate shielding is provided. Research on prediction techniques, one of NASA's objectives, should be vigorously pursued in parallel with human exploration programs. The intent would be to provide the

earliest possible warnings, with minimal false alarms, of impending solar flares and flare particles.

As the 90-Day Study indicates, it is important to learn more about the relative biological effects of radiation fluences, particularly high-Z galactic cosmic rays and solar flare electrons and protons, and their relationship to cancer and cataract induction, for example, in order to set meaningful guidelines for radiation protection. The question of appropriate shielding in flight, at an Earth-orbiting station, and on the Moon and Mars is complex and requires further study. For example, NASA suggests that for modest thicknesses of shielding, the secondary radiation arising from the interaction of galactic cosmic radiation may be more harmful to living tissue than the primary dose. Consideration should be given to undertaking early flights during solar minimum conditions.

Controlled Environment Life-Support Systems

The 90-Day Study recognizes the challenge of providing a reliable, cost-efficient life-sustaining environment in locations that are devoid of food, air, water, and nutrients. NASA's vision of the HEI uses closed-loop systems where practical to reduce logistic requirements and open-loop systems where limitations in technology or operational capabilities dictate.

It would be useful, but not mandatory, to have fully-closed life-support systems for brief visits to the Moon and to Mars. However, even for a brief visit, it is desirable to recycle water. For prolonged stays on the Moon and Mars, a completely closed regenerative system would be highly desirable to reduce requirements for resupply. Several terrestrial closed-loop experiments are under way and must be reviewed in the context of the HEI and refined until they are successful. The next step should be a test bed of a closed life-support system in microgravity on or near an Earth-orbiting station.

Contamination and Back Contamination

Evidence from the Viking missions to Mars suggests that terrestrial microorganisms have little or no probability of growth on that planet, but that does not rule out the possibility that life exists or may have existed there in the past. Although organic compounds and liquid water have not been detected on Mars, there is no basis for precluding their existence. There is, moreover, strong evidence that liquid water in large quantities existed in the Martian past. Furthermore, new discoveries about unusual biological niches on Earth, such as deep ocean thermal vents, illustrate the diversity of biological habitats.

International law requires that activities in space be conducted to avoid the harmful contamination of celestial bodies as well as introduction

of changes in the Earth's environment by extraterrestrial matter. For example, a Mars robotic lander raises concerns about contamination of Mars (referred to as forward contamination), while a Mars sample return mission must deal with concerns about contamination of Earth (called back contamination).

The NASA 90-Day Study envisions a series of unmanned precursor missions to Mars to determine characteristics of the planet. The knowledge to be obtained is necessary for detailed mission planning, including dealing with the contamination issue. The Great Exploration concept does not include such precursor missions. The committee believes that, before humans go to Mars, there will have to be a highly capable set of precursor missions, whose precise definitions, numbers, and configurations require detailed research strategy development. Such precursor missions will allow assessment and management of some of the risks of carrying out a manned mission. The risks are not limited to concerns simply with pathogens. While the risk of pathogens is admittedly low, the potential costs are possibly very high.

Psychological Issues

As noted in the 90-Day Study, psychological effects arising during long-duration sequestering of humans have been documented, for example, in nuclear submarines and research programs in Antarctica. Although these terrestrial analogs are useful, they do not adequately simulate conditions of long-duration missions to Mars. NASA appropriately envisions continuing research in the selection process for spacefarers. Issues of spacecraft habitability, training and command structure, as well as crew mix require study, including simulation. A review of research results to date indicates that more is known about avoiding undesirable crew characteristics than is known about selecting crew for desirable traits. Clearly, the psychological profiles for individuals and for crew composition should be well understood, to reduce risks on long voyages. As is the case with most risks to humans arising from long stays in the microgravity environment, technological advances in nuclear and other propulsion systems could alleviate some adverse effects by reducing mission duration.

Physical Sciences

Because the use of local resources is likely to be an essential feature of the mission architecture, additional scientific knowledge will be required about surface materials, features, and structures, both on the Moon and Mars. Four of the five reference approaches in the 90-Day Study incorporate extraction of oxygen from lunar materials.

Present knowledge of lunar and Martian surface features is adequate for lander modules, provided that high-resolution imagery is incorporated for terminal guidance to a landing that can be directed over a sufficiently large target radius. Additional knowledge will be required for site selection, however, if the astronauts will be expected to carry out significant research while on the surface. Uncertainties also exist concerning the bearing strength of the Martian surface in areas of possible landing sites.

In the case of the Moon and a possible long-term lunar base, the flux of micrometeorites and its variability are major uncertainties that can affect the livability of a lunar station. As described in both the 90-Day Study and The Great Exploration, covering the station with lunar regolith is one possible way to reduce the hazards from micrometeorites and radiation.

A fuller examination of research emphases in this area is needed before precursor mission concepts are developed.

RESEARCH OPPORTUNITIES TO BE DERIVED FROM PROLONGED HUMAN SPACE MISSIONS

The NASA 90-Day Study describes a variety of opportunities presented by the HEI to advance scientific understanding through both the robotic and human exploration phases of the HEI. The opportunities are organized into a series of scientific themes. Several themes pose questions that challenge astronomers, and NASA notes, for example, that the Moon offers a number of advantages as a site for astronomical observatories.

The committee believes the Moon could offer potentially unique research opportunities for a number of space science disciplines, including astronomy. However, the concept of an astronomical observatory on the Moon needs to be examined more critically than was suggested in the NASA report. Specifically, lack of seismic activity does not seem to be a major feature in determining whether the Moon should be used for interferometry. Attractive features include the dark and cold sky advantages that come from being away from the Earth, and the advantages of building large structures in fractional gravity.

Before establishing a lunar base to be used for scientific research, a number of significant issues need to be understood in order to ensure the long-term utility of the base for research purposes. For example, depending upon the specific research objectives, evaluations should be made of the effects on instrumentation of such features as the micrometeorite flux, the solar wind and solar flare particles, and the electric and magnetic environments on the surface at different lunar phases. In addition, attention will have to be given to the interactions between a human presence and specific scientific instrumentation (e.g., outgassing, vibration, dust, and electromagnetic interferences).

Additional research opportunities on and from both the Moon and Mars are sketched in the 90-Day Study. There will undoubtedly be opportunities for the HEI and the space sciences to advance together. Each scientific opportunity to be derived from human space exploration should be defined and evaluated, with consideration of its relative priority in the research strategy of the appropriate discipline, and an assessment of the most effective means to achieve it.

V

Nontechnical Considerations

In addition to questions of the technical and scientific merit of specific approaches, the committee examined challenges to the HEI concerning infrastructure and management, ways in which HEI might stimulate the educational process, questions of international cooperation and collaboration, and ways to look at the costs of such an undertaking.

INFRASTRUCTURE CONSIDERATIONS

The Responsible Federal Entity

Under the Space Act of 1958, NASA was assigned the lead federal responsibility for the conduct of the nation's civil space program for research and exploration. In support of its assigned role, it also undertakes selected developmental and operational functions with Administration direction and budgetary approval.

NASA is currently well below the peak manpower and budget that it had during the Apollo era, yet it carries a number of demanding tasks. These include the operation of the Space Transportation System (STS); the conduct of a major series of Earth-orbital and planetary scientific missions, including Galileo, the Hubble Space Telescope, and Mission to Planet Earth; the operation of a major space and terrestrial communication system; the aeronautics research and development program; the development of Space Station Freedom; and a large number of smaller programs.

The major responsibilities listed above leave little room to assume responsibility for a program that could, in some variants, equal in size and complexity nearly all of the existing programs in aggregate. This raises questions of whether NASA should be expanded (via some combination of increases in civil service manpower, contractor support, or support from other federally supported entities), whether the responsibilities for HEI should be spread across several agencies, or whether all or some of the responsibilities should be transferred to a new or existing organization.

In the committee's view, NASA has the organizational expertise and demonstrated capability to conduct human space exploration. The development of that expertise and the associated laboratories and other facilities has been hard won at great national expense. To attempt to replicate such expertise elsewhere would be costly and time consuming. Yet, the long-term human exploration initiative will require that NASA and the nation develop a whole new generation of management and technological leadership.

The NASA Infrastructure

This is not to say that NASA should automatically be authorized to return to Apollo-era civil service staff levels (or even greater) to lead the HEI, although an increase may be part of some options. To proceed effectively with the HEI, the Administration should develop a plan to incorporate other federal resources that can support the HEI, as well as devise innovative uses of the private sector, universities, and federally supported research centers. It is conceivable that a new federally supported center in the mold of Bellcom, the Jet Propulsion Laboratory, the Mitre Corporation, or the Aerospace Corporation may have a role to play in various aspects of the program, although this requires further examination.

Efficient conduct of the HEI will require a number of management enhancements, some of which must counter difficulties that are government-wide.

First, NASA's procurement process should be carefully scrutinized to identify means of expediting it so it is less burdensome to both NASA and those bidding for NASA tasks. Some procurement processes, which are not unique to NASA, absorb time and increase costs. Administrative procedures must be subjected to the same cost-benefit analysis as technical approaches. Solutions to this difficulty are not within NASA's authority, although NASA can lead an analysis for joint NASA-Administration-Congressional action. NASA now has an opportunity to study and possibly implement techniques to simplify and improve procedures, and these approaches should be included in the HEI or any *de novo* program.

Second, it is too costly for the nation to rethink its objectives in space on an annual basis. Long-term objectives must be set and technical

program managers given the consistent support required for the efficient pursuit of the challenging engineering and scientific objectives to meet the President's goals. Recent experience on programs such as Space Station Freedom has demonstrated the difficulties that result when a program's entire management team is consumed by phasing, rephasing, planning, replanning, rescoping, and descoping a program in ceaseless variation.

Third, proceeding with the HEI will require that the Administration and Congress give serious attention to restoring or at least retaining the basic attractiveness of NASA employment, including competitive salaries. While NASA has exciting programs that interest the nation's engineering and science communities and many young people, NASA—like other federal agencies—is losing its appeal as an employer. In addition, the skills of NASA personnel, who offer an important long-term continuity in the execution of programs, need continual enhancement.

Fourth, positive steps are needed to encourage young people to enter science and engineering careers, some of whom will enter NASA, space-related industry, or university programs. A program of the size and scope of the extended human exploration of the Moon and Mars will severely tax a US educational system that is already strained and that is producing a declining number of trained engineers and scientists. Early in the history of the US space effort, a direct stimulus expanded the participation by universities in space activities and increased the number of graduate students studying and researching space-related subjects. It again appears essential to revitalize such activities if the human resources are to be available that the exploration mission will require. Such a revitalization could have the additional benefit of attracting more young people into scientific and engineering careers.

International Considerations

The committee considered the goals and proposed implementation of the HEI from the viewpoint of US interests and national capabilities only, using the same assumptions as the NASA 90-Day Study in this regard. Thus, the findings and conclusions here are consistent with an all-US exploration program. However, it is apparent that several important benefits could accrue from international cooperation and collaboration on these programs.

The current technical and political climate is different from that which existed earlier in the space age. The European Space Agency (ESA) has developed considerable applicable expertise for human space flight through Spacelab and its development of Columbus and Hermes. Japan has similarly developed expertise in pressurized modules. Both ESA and Japan have independent launch capabilities and growing expertise and interest

in space exploration. Canada's contribution in remote manipulators and robotics could prove very valuable in remote lunar and Mars exploration. Other nations less active in previous joint space ventures may also wish to participate in this long-term venture. Most importantly, the USSR has substantial relevant capability, demonstrated continued interest in Mars, and an apparent strong desire for cooperation with the US in Mars exploration. The USSR has substantial experience in long-duration (one year) human exposure to weightlessness, and the capability, with its space station *Mir*, to undertake multiyear studies and evaluations of countermeasures. The *Energia* has a considerable heavy lift capability, launched from its current facility. This capability would be reduced were Earth orbit rendezvous with Space Station Freedom desired because of the power and maneuverability required to dramatically change the spacecraft orbit.

Several potential advantages of international participation in HEI are evident. These include cost sharing, additional technical expertise, and peaceful cooperation in a multidecade program of interest to all mankind. Some potential disadvantages include possible dependence on foreign countries for critical activities, concern over transfer of US technology, and more complex management interfaces.

Considerations of the advantages and disadvantages should recognize that international collaboration requires long-term policy stability, and that the US record is not exemplary in this regard. If collaboration is contemplated, care must be taken to ensure that the enabling agreements are supported at the highest possible levels in the participating governments, with as much breadth as is feasible, and that detailed technical agreements are not made final before all parties understand and agree on requirements for the HEI or missions associated with it.

As noted earlier, the climate for international cooperation is changing and is likely to continue to change. A detailed assessment is needed of the opportunities for international cooperation that may be available and the means to overcome technical and institutional barriers. It would be prudent to remain alert to future opportunities that may arise.

Cost for the Human Exploration Initiative

By any measure, HEI will represent a major commitment of the nation's resources; it will be a multiyear program; it will involve deliberate risk, often difficult to identify and quantify; and it will use major portions of the careers of many dedicated people. For HEI to be undertaken successfully there is a clear need for a unique long-term commitment by successive Administrations and the Congress. In the committee's view, estimates of the costs likely to be incurred in carrying out the HEI are uncertain—and

are likely to remain so for some time. The initiative is an ambitious undertaking that requires development and implementation of new technology. If the costs or schedule of an ambitious, daring technical advance can be estimated accurately, it is probably using obsolete technology and is neither ambitious nor daring. Accurate cost estimates are only practical in circumstances where experience with the technology exists. Currently, the technologies and even the HEI mission architectures are unknown. While the nation has experience with estimating costs of some aspects of HEI, derived from experience with the costs of past space systems, at this time mission cost estimates should only be taken as suggesting the rough order of magnitude of the eventual costs.

Analyses of past major programs have shown that there is an optimum rate of activity that results in minimum total cost. If the pace is faster, it costs more. If the program is stretched out, the total cost can also be greater. In most past experiences, space projects based on the logic of development and mission requirements usually have required high peaks in the funding profile and have resulted in demands for annual funding greater than was considered acceptable. Therefore, most programs have been stretched out and the total cost has not been optimized.

At this stage it may be useful to think about costs in terms of the level of effort that is both reasonable for making progress toward the President's goal and sustainable as a commitment of national resources over the long run. In the peak spending year of the Apollo program, which was in the nature of a race to the Moon, the NASA budget amounted to about 0.8 percent of the gross national product (GNP), or 3.85 percent of the total federal budget. The total expenditure for Apollo (which averaged about 0.2 percent of the GNP) was approximately \$24.5 billion (\$118.1 billion in 1991 dollars). Apollo was a ground-breaking program that incurred substantial cost to build facilities and institutions; government and industry put forth a unique effort to fulfill the vision of President Kennedy. The HEI will presumably build on this capacity and will almost certainly take longer. President's Bush's vision includes a permanent presence in space, requiring a continuing commitment of resources.

The committee believes it should be possible to return people to the Moon and establish a human presence on Mars, at a measured pace, at a relative rate of annual expenditure that is less than that of the peak Apollo commitment. NASA's current budget is between 0.2 and 0.3 percent of the GNP. The committee believes an additional national commitment of resources of a few tenths of one percent of the GNP should be sufficient to achieve and sustain the goal of the HEI, the permanent presence of humans in space. A commitment of this sort, which extends far into the future, could enable the selection of an appropriately phased mission architecture as well as research and development strategies and would enable managers

to establish practical schedules. Continuing analysis of the relationship between rates of expenditure, technology development, and mission profile is obviously warranted.

HEI will involve a continuing commitment and, for such an approach to succeed and to maintain support from the American people, it should set milestones and demonstrate visible accomplishments, for example every two to three years.

A White Paper published by the National Research Council in early 1989 recommends that NASA maintain a balanced, stable base program to ensure US competence in fundamental space activities such as astronomy, planetary exploration, and Earth remote sensing. The committee believes that this base program should be assured as the nation undertakes additional large, special initiatives such as the human exploration of the Moon and Mars. The committee believes that it is important for the funding support for HEI and other major initiatives to continue to be distinct from that for the remainder of the NASA budget, to avoid eroding the base of other essential space and aeronautical capabilities.

VI

Summary Responses to Questions Posed by the Vice President

In his charge to the committee, the Vice President posed a series of specific questions. The committee's responses, taken from the body of the report, follow:

SCOPE OF THE REPORT OF THE NASA 90-DAY STUDY

1. Does the report address the widest possible range of technically credible approaches to meeting the President's exploration goals? If not, what additional areas warrant exploration?

The NASA report addresses a reasonable set of technological and strategic approaches, but not all of the technically credible approaches have been analyzed. Other approaches have been discussed in the past, and many of those have been examined by NASA. The National Commission on Space, for example, included in its recommendations cycling spaceships between Mars and Earth orbits using electric propulsion.

Regarding additional areas that warrant consideration, the committee believes it prudent to await better understanding of significant life sciences issues before deciding the detailed architecture for sending humans to Mars. The committee further believes that precursor missions, such as the Mars Observer, are essential to understanding the Martian environment and to determining appropriate landing sites, for example for exploratory landers that might be sent from a Mars orbiter.

2. [Over the next 30 years] what are the likely areas for technical breakthroughs relevant to space exploration? Has the report fully taken these into account?

Likely areas for technical advances include nuclear power, propulsion, and conversion technologies for space applications; controlled environmental life support systems; sophisticated human/machine systems; physiological and psychological countermeasures to the space environment; effective artificial gravity; and the intertwined technologies in computer science and artificial intelligence that provide for better information management. Technologies to lower the cost of access to space probably will become available, including advanced materials and a new generation of cryogenic engines. Some of the breakthroughs and evolutionary development will come principally from human exploration research and development; others will evolve whether or not humans explore space, but can benefit from the exploration initiative.

The NASA report is prudently based largely on incremental advances in technology and does not depend on breakthroughs. Aerobraking technology is scheduled for demonstration in the near future. Nuclear propulsion, although not critical to the reference approaches, would represent a breakthrough and will require demonstration prior to commitment to its use.

3. Is the range of science goals and objectives commensurate with the proposed technical capability? Does the report distinguish between critical or enabling science and complementary science?

Clearly, technical capabilities are of paramount importance to the HEI. Nevertheless, worthwhile research can be done in conjunction with the HEI if research strategies are developed by weighing (1) the scientific priority of a given research activity, and (2) whether that research might best be accomplished by another means.

Although not well distinguished from complementary science in the NASA report, the enabling research in life sciences is crucial to productive and safe human occupancy of space. Other areas of enabling science include research on the nature of the Martian atmosphere and research and technology development for the use of in-situ resources.

4. Are there implications (infrastructure-institutional/other national interest) that have not been considered?

The NASA study recognizes the need for personnel, facilities, and equipment to fulfill the HEI. As noted in the report, NASA's current facilities and civil service personnel complement may need augmentation

to address the HEI. The program, led by NASA, should be designed to draw on the resources of other federal agencies. The HEI needs to be conducted with greater efficiency than are most federal programs. As the NASA report notes, the HEI “. . . presents a unique opportunity to demonstrate the viability of streamlined administrative and management processes.” Procurement and budgeting obstacles are also recognized in the report.

NASA believes that international partners should be included in the early definition of HEI. While it is important to work together with other nations, the committee believes it is necessary to understand the HEI mission designs and architectures before making commitments. The report defines varying approaches to international cooperation, including “separate, but coordinated,” “augmentation through cooperation,” “interdependence with clear interfaces,” and “joint development and operation,” but NASA will need policy guidance about the right approach to employ as the HEI progresses.

CONTENT OF THE REPORT OF THE 90-DAY STUDY

1. What are the report's technical assumptions? Are they reasonable?

The report assumes continuing dependence upon the space shuttle and shuttle-derived vehicles. Some of the reference approaches assume acceleration of the availability of Space Station Freedom (SSF) and all assume that the station will become operational by the late 1990s. Operation of the station by the late 1990s appears to be a reasonable assumption. Present plans for the station, however, are not adequate to satisfy HEI life sciences needs. At this time, it is also uncertain whether the station will be the most appropriate staging base for the Moon and Mars.

The report does not assume that the Advanced Launch System will materialize, but observes that such vehicles could be used to great advantage were they available. It does not assume nuclear rockets or power, but indicates that they could be useful were they available.

2. Are there innovative uses of existing technology that the report has overlooked?

There undoubtedly will always be new ways to do things based on existing technology. That said, however, none were obvious in reviewing the NASA report and alternative scenarios. In considering this question, the committee did not regard paper studies to be existing technology, due to the uncertainties involved in experimentally proving the concepts. Inflatable space modules, on the other hand, have had several NASA prototypes; but the applications for which they can be used are uncertain. SSF modules

do not yet exist, but the nation has built a space station before and knows a lot about how to do it. Use of SSF modules for bases and orbiters is a concept based on use of existing technology.

3. Are the cost estimates and schedules reasonable?

NASA has conducted exercises to estimate the order of magnitude of costs of the HEI using several cost models derived from experiences with past space systems. Accurate cost estimates, however, are only possible in circumstances where experience with the technologies exists and where objectives are clear. As a general rule, the greater the technical risk inherent in a mission approach, the larger the uncertainty.

The HEI schedule will take into consideration other national resource commitments, which should be set by the social and political process, with scientific and technical input. The schedules presented in the NASA document are therefore not highly relevant, but do serve as a backdrop against which to assess various cost scenarios and mission options.

It will not be possible to meet cost or schedule estimates without a clear, long-term commitment from the executive and legislative branches of government. In addition, a program subjected to repeated phasing and rephasing cannot meet schedule and cost targets.

- Are there alternative ways the schedule might be moved forward to provide visible, near-term accomplishments?

NASA's Reference Approach B represents one option that advances Mars exploration from 2018 to 2031, but it depends upon accelerating completion of Space Station Freedom. For technical and cost reasons, such acceleration seems unlikely.

Concepts such as the Great Exploration, using as yet unproven inflatable technologies and expedited procurement procedures, and concepts based on using space station modules for orbiters and bases could potentially enable a return to the Moon and human exploration of Mars earlier than the NASA reference missions. However, an adequate infrastructure for potential future needs would need to be built separately.

Another alternative is a scenario where initial missions to Mars would have limited capabilities. Beyond questions of technical feasibility, the question of how elaborate the initial human missions need to be should be examined. This could involve trade-offs between up-front investments for technology development (which can reduce long-term operating costs for many future missions) and low up-front investment focused on near-term objectives, an approach that will save money in the present but that may eventually lead to more expensive operating costs.

The committee believes that almost any approach to HEI can have visible, near-term milestones. Humans living and working on the Moon,

construction of habitats, and scientific and mining facilities can all provide evidence of accomplishments in space.

- Similarly, are there alternate routes which could dramatically increase performance, lower costs, move the schedule forward, or reduce risks? If so, what levels of programmatic and technical risk do they have?

The alternatives that the committee examined to move forward the schedule for lunar and Mars bases entailed higher levels of programmatic, technical, and human risk than the NASA reference approaches, as well as lesser capabilities.

The levels of uncertainty in estimating costs for these alternatives are so high that it is not possible to determine which among the approaches reviewed offers the potential for lower costs. Once again, the most dramatic alternate route to increase performance would be the development of safe nuclear propulsion for interplanetary travel.

4. Are the overall approaches/architectures described in the report reasonable? For example, are the key elements of NASA's plan consistent, i.e., availability of the space station, heavy lift vehicles, etc.?

Yes, the committee believes the overall approaches described in the report are reasonable. The treatment of nuclear power and propulsion, however, appears to be somewhat ambiguous. Nuclear power on the Moon is seen as essential in the 90-Day Study, but scenarios are also provided that rely on solar dynamic power. Nuclear propulsion is listed as a critical technology for development, yet none of the reference approaches call for it. Given the developmental and societal uncertainties concerning nuclear power, however, the treatment of this matter is not unreasonable.

In general, the key elements of the NASA document are consistent. For example, a given scenario does not rely on the station or technology development without considering the time needed for it to be established or developed. A space station in LEO is considered essential for all of the scenarios; however, the requirements of the HEI may not be fully met by Space Station Freedom.

Last, the committee believes that, whatever the selected architecture for HEI, there is a need for a new emphasis on advanced technology development and that it is highly desirable to continue to cast a wide net for innovative concepts.

Biographical Sketches of Committee Members

H. GUYFORD STEVER has had a career as a scientist, engineer, educator, and administrator. He was Science Advisor to Presidents Nixon and Ford and concurrently was Director of the National Science Foundation (1972-1976). Earlier, he was President of Carnegie-Mellon University and Chief Scientist of the Air Force. Dr. Stever was Professor of Aeronautics and Astronautics at the Massachusetts Institute of Technology, as well as head of the Departments of Mechanical Engineering and Naval Architecture and Marine Engineering. More recently, he was President of the Universities Research Association and Foreign Secretary of the National Academy of Engineering. He currently serves on the Carnegie Commission on Science, Technology, and Government. He is a member of the National Academies of Sciences and Engineering. After the Challenger accident, he headed the National Research Council's Solid Rocket Booster Redesign Panel and was awarded the NASA Distinguished Public Service Medal. In 1989 he chaired the National Academy of Sciences/National Academy of Engineering study that led to the White Paper, "Toward a New Era in Space."

ROBERT H. CANNON, JR., is Charles Lee Powell Professor and Chairman of the Department of Aeronautics and Astronautics at Stanford University. His research interests include precision control of very flexible manipulators for robots and spacecraft and the space gyro experiment to test the general theory of relativity. Previously, he was Professor of Engineering and Chairman of the Division of Engineering and Applied Science at the California Institute of Technology. Between 1970 and 1974

he was US Assistant Secretary of Transportation. Prior to that he had been Chief Scientist of the Air Force, a professor at the Massachusetts Institute of Technology, and a researcher in flight control and inertial navigation systems in the aviation industry. He is a member of the National Academy of Engineering, the National Research Council's Aeronautics and Space Engineering Board, and Chairman of NASA's Flight Telerobotics Servicer Advisory Committee. He has served as Chairman of the National Research Council Assembly of Engineering and as Chairman of the President's Commission on the National Medal of Science. Dr. Cannon holds several patents and has published extensively on such subjects as the environmental impact of stratospheric flight and automatic controls for aerospace vehicles.

JOSEPH G. GAVIN is a Senior Management Consultant for Grumman Corporation. He was elected President of Grumman in 1976 and retained this position until February of 1985, when he was elected Chairman of the Executive Committee. Mr. Gavin retired from Grumman in September of 1985. He was named the Aerospace Educational Council Man of the Year in 1968. In 1971, NASA awarded him its Distinguished Public Service Medal for his contributions "as the leader and representative of the Lunar Module team at Grumman." He was chief of the Grumman missile and space engineering program and director of the Lunar Module Program throughout the Apollo years. Mr. Gavin is a Fellow of the American Institute of Aeronautics and Astronautics and the American Astronautical Society and a member of the National Academy of Engineering and the Aerospace Industries Association. He recently served as a panel member on the Department of Energy Advisory Board's International Thermonuclear Experimental Reactor Working Party, as a board member of the American Association for the Advancement of Science, and as a member of the Executive Committee of the Massachusetts Institute of Technology.

JACK L. KERREBROCK is a Fairchild Distinguished Scholar at the California Institute of Technology for 1990 and Richard Cockburn Maclaurin Professor of Aeronautics and Astronautics at the Massachusetts Institute of Technology since 1975. Before that he headed the MIT Department of Aeronautics and Astronautics and was Associate Dean of Engineering at MIT. Dr. Kerrebrock was Associate Administrator for Aeronautics and Space Technology of NASA from 1981 to 1983. He has taught and conducted research in energy conversion and propulsion since 1956, when he received his PhD degree from the California Institute of Technology. His early work was on nuclear rockets, space propulsion and power, and magnetohydrodynamic generators. More recently, he has addressed the fluid mechanics of turbomachinery for aircraft engines and gas turbines. He was Director of the MIT Gas Turbine Laboratory from 1968 to 1978. Dr. Kerrebrock is a past and present member of several governmental advisory

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LOUIS J. LANZEROTTI is a Distinguished Member of the Technical Staff of AT&T Bell Laboratories, where he has worked since receiving his PhD from Harvard in 1965. Dr. Lanzerotti is concurrently an Adjunct Professor at the University of Florida, and his principal research interests include studies of planetary magnetospheres, energetic particles emitted by the sun, and the impacts of space processes on space and terrestrial technologies. Dr. Lanzerotti is a member of the National Academy of Engineering and the International Academy of Astronautics, and is a Fellow of the American Physical Society, the American Association for the Advancement of Science, and the American Geophysical Union. He has served on numerous NASA and National Science Foundation advisory committees concerned with space and solar-terrestrial research, chaired NASA's Space and Earth Sciences Advisory Committee, and is currently Chairman of the National Research Council's Space Studies Board. He is a recipient of NASA's Distinguished Public Service Medal.

ELLIOTT C. LEVINTHAL is a Research Professor of Mechanical Engineering and Associate Dean for Research at Stanford University as well as Director of the Stanford Institute for Manufacturing and Automation. Previously, he has served as Director of the Defense Science Office of the Defense Advanced Research Agency, Professor (Research) of Genetics in the Stanford School of Medicine, Director of the Stanford Instrumentation Laboratory, Chief Engineer of Century Electronics, President of Levinthal Electronics Products, Inc., and Director of Research of the Instrumentation Division, Varian Associates. His research areas include applications of computers to image processing and medical instrumentation, exobiology, planetary sciences, and manufacturing science. Dr. Levinthal received his PhD from Stanford and is a member of the National Research Council's Space Studies Board and the Army Sciences Board.

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JOHN H. McELROY is currently Dean of Engineering at the University of Texas at Arlington. He was formerly Vice President for Technology of Hughes Communications, Inc., a subsidiary of the Hughes Aircraft Company. Dr. McElroy joined Hughes in 1985 as Director of Special Projects in the Space and Communications Group, after serving as Assistant Administrator of the National Oceanic and Atmospheric Administration, where he directed the nation's program in civil operational Earth observations from space. From 1966 to 1982, he served with NASA, where his last position was Deputy Director of Goddard Space Flight Center. He previously performed laser research at the Quantum Electronics Research Laboratory at the University of Texas at Austin and taught electronics in the US Army's air defense guided missile program. Dr. McElroy is a Fellow of the Institute of Electrical and Electronics Engineers, the American Institute of Aeronautics and Astronautics, and the Washington Academy of Sciences. He serves on many advisory committees and is Chairman of the National Research Council/Aeronautics and Space Engineering Board Committee on Advanced Space Technology.

DUANE T. McRUER is President and Technical Director of Systems Technology, Inc. He is a member of the National Academy of Engineering and the National Research Council Aeronautics and Space Engineering Board, and a Fellow of the Institute of Electrical and Electronics Engineers, the American Institute of Aeronautics and Astronautics, the Society of Automotive Engineers, and the Human Factors Society. He has chaired NASA subcommittees on Avionics, Control and Guidance and the National Research Council Committee on Space Station Engineering Design Issues. He was a member of the NRC Committee on a Commercially Developed Space Facility as well as NASA's Aeronautics Advisory Committee. Mr. McRuer's research interests are in control systems engineering, manual and automatic flight control and guidance for aerospace and land vehicles, man-machine systems, and dynamics of human operators.

WILLIAM J. MERRELL, JR., is the President of Texas A&M University, Galveston, and a Rear Admiral in the U.S. Maritime Service. He

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ROBERT H. MOSER is a physician and educator who has been Vice President for Medical Affairs at The NutraSweet Company since 1986. He served as flight controller of Project Mercury, consulting member of the medical evaluation team for Project Gemini, and consultant to Project Apollo. From 1984 to 1987 he was Chairman of the NASA Life Sciences Advisory Committee. Dr. Moser received his MD from Georgetown University and entered the Army, where he held many positions, including that of battalion surgeon in Korea; Chief of Medical Services for the US Army Hospital, Salzburg, Austria; Assistant Chief of Medicine, US Army Tripler General Hospital; Chief of Medicine, William Beaumont General Hospital; Chief of Medicine, Brooke Army Hospital; and Chief of Medicine, Walter Reed General Hospital. Dr. Moser retired in 1969 to become Chief of Staff of the Maui (Hawaii) Memorial Hospital and Clinical Professor of Medicine at Hawaii University from 1969 to 1977, at present is Adjunct Professor of Medicine of Northwestern University Medical School and Uniformed Services University of the Health Sciences, and Executive Vice President of the American College of Physicians from 1977 to 1986. He is the author of *Diseases of Medical Progress* and has contributed over 150 articles to medical science journals and medical books. He is a member of the National Research Council's Space Studies Board.

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Bibliography

- Allen, John, and Mark Nelson. 1986. Space Biospheres. Synergetic Press, Inc.
- American Astronautical Society (AAS). 1985. The Case for Mars II. Edited by Christopher P. McKay. Vol. 62, Science and Technology Series. Univelt, Inc., San Diego, Calif.
- AAS. 1988. The NASA Mars Conference. Edited by Duke B. Reiber. Vol. 71, Science and Technology Series. Univelt, Inc., San Diego, Calif.
- American Institute of Aeronautics and Astronautics/Jet Propulsion Laboratory (AIAA/JPL). August 1989. Second International Conference on Solar System Exploration. General Chairperson: John Casani.
- Bekey, Ivan. 1989. A Smaller Scale Manned Mars Evolutionary Program. International Astronautical Federation (IAF), 40th Congress, preprint IAF-89-494.
- Bialla, Paul H., and M.C. Simon. 1989. The Liquid Rocket Booster as an Element of the US National Space Transportation System. IAF, 40th Congress, preprint IAF-89-294.
- Black, David C. September 26, 1989. Statement in Support of Testimony to the Subcommittee on Space Science and Applications, Committee on Science, Space, and Technology. US House of Representatives.
- Clark, Benton C. 1989. Artificial Gravity Mars Spaceship. IAF, 40th Congress, preprint IAF-89-025.
- Cohen, Aaron, et al. November 1989. Report of the 90-Day Study on Human Exploration of the Moon and Mars. National Aeronautics and Space Administration.
- Craig, Mark K. 1988. Integrated Strategies for the Exploration of Mars. IAF, 39th Congress, preprint IAF-88-391.
- Crimmins, Rob, and David Chirdon. December 4, 1989. Final Report for: Conceptual Design Study for Modular Inflatable Space Structure. ILC Dover, Inc. ILC Project 012-021.
- DeVincenzi, D.L., and H.P. Klein. 1989. Planetary Protection Issues for Sample Return Missions. Advanced Space Research (ASR), Vol. 9, No. 6, pp. 203-206.
- DeVincenzi, D.L., P.D. Stabekis, and J.B. Barengoltz. 1983. A Proposed New Policy for Planetary Protection. ASR, Vol. 3, No. 8, pp. 13-21.
- Dixon, Franklin P. 1989. Manned Planetary Mission Studies from 1962 to 1968. IAF, 40th Congress, preprint IAA-89-729.
- Duke, Michael B. 1989. Lunar Oasis. IAF, 40th Congress, preprint IAA-89-717.

- Grallert, H.K.H., S.G. Furniss, and F.A. Hewitt. 1989. An Investigation of Future European Winged Launcher Concepts. IAF, 40th Congress, preprint IAF-89-216.
- Gubanov, B.I. 1989. Energia—A New Versatile Rocket-Space Transportation System. IAF, 40th Congress, preprint IAF-89-202.
- Hannigan, Russell J. 1989. The Economic Impacts on Space Operations of Future Launch Systems. IAF, 40th Congress, preprint IAA-89-697.
- Henry, Gen. Richard C. January 17, 1990. Workhorse Launch System, Assured Access to Space, An Affordable Approach.
- Hunter, Maxwell W. March 11, 1989. The SSX, Spaceship, Experimental.
- Institute of Ecotechnics. 1985. The Biosphere Catalogue. Synergetic Press, Inc.
- Lanes, Stephen J. January 18, 1990. Briefing on the Department of Energy's Radioisotope Power Program. Space and Defense Power Systems, US Department of Energy.
- Lawrence Livermore National Laboratory (LLNL). October 4, 1989. An American-Traditional Space Exploration Program: Quick, Inexpensive, Daring and Tenacious. LLNL Doc. No. PHYS.BRIEF 89-405.
- LLNL. October 5, 1989. The First Step: Demonstrating the Key Technologies for The Great Exploration. LLNL Doc. No. PHYS.BRIEF 89-404.
- LLNL. December 14, 1989. Issues and Answers: NASA Remarks on The Great Exploration Program and LLNL Responses. LLNL Doc. No. PHYS.BRIEF 89-407.
- LLNL. January 1990. NASA Assessment of the LLNL Space Exploration Proposal and LLNL Responses. LLNL Doc. No. SS 90-9.
- LLNL. January 17, 1990. The Great Exploration Plan for the Human Exploration Initiative. LLNL Doc. No. PHYS.BRIEF 90-402.
- Leyse, C.F., W.W. Madsen, J.H. Ramsthaler, and B.G. Schnitzler. August 1989. Pressure Fed Nuclear Thermal Rockets for Space Missions. Prepared for the US Department of Energy, Idaho Operations Office under DOE Contract No. DE-AC07-76ID01570.
- McSween, Harry Y., Jr. November 1985. SNC Meteorites: Clues to Martian Petrologic Evolution? Reviews of Geophysics, Vol. 23, No. 4, pp. 391-416.
- Murray, Bruce. September 1989. Statement to the Subcommittee on Space Science and Applications of the Committee on Science, Space and Technology. US House of Representatives.
- National Academy of Sciences, National Academy of Engineering (NAS/NAE). 1988. Committee on Space Policy. Chairman: H. Guyford Stever. Toward a New Era in Space, Realizing Policies to New Realities. National Academy Press, Washington, D.C.
- National Aeronautics and Space Administration (NASA). August 15, 1963. Office of Manned Space Flight. Study of a Manned Mars Landing Mission Using a Mars Orbit Rendezvous Profile.
- NASA. 1969. America's Next Decades in Space: A Report for the Space Task Group. MSFC-69-PD-SA184.
- NASA. January 1976. Outlook for Space: Report to the NASA Administrator by the Outlook for Space Study Group. NASA SP-386.
- NASA. 1983. Advisory Council, Solar System Exploration Committee. Planetary Exploration Through Year 2000: Part One: A Core Program. US Government Printing Office, Washington, D.C.
- NASA. 1984. Scientific and Technical Branch. Ezell, Edward Clinton, and L. Nneumen Ezell. On Mars: Exploration of the Red Planet 1958-1978. NASA SP-4212.
- NASA. 1986. Advisory Council, Solar System Exploration Committee. Planetary Exploration Through Year 2000: Part Two: An Augmented Program. US Government Printing Office, Washington, D.C.
- NASA. October 12, 1987. Advisory Council, Task Force on International Relations in Space. International Space Policy for the 1990's and Beyond.
- NASA. 1988. Office of Exploration. Beyond Earth's Boundaries: Human Exploration of the Solar System in the 21st Century. Report to the Administrator.
- NASA. 1988. Office of Exploration. Technical Report, Vols. I-III. Technical Backup to Beyond Earth's Boundaries.
- NASA. 1989. Long Range Program Plan.

- NASA. June 2, 1989. Life Support Management Working Group (LSMWG). Final Report, Life Support Management Working Group.
- NASA. June 2, 1989. LSMWG. Final Report on the Results of the LSMWG, Appendices.
- NASA. October 1989. Space Life Sciences. Human Exploration Initiative. Life Support Systems Reference Program Plan. Life Sciences Division, Office of Space Science and Applications.
- NASA. October 1989. Space Life Sciences. Human Exploration Initiative. Medical Support Systems Reference Program Plan. Life Sciences Division, Office of Space Science and Applications.
- NASA. November 1989. Cohen, Aaron, et al. Report of the 90-Day Study on Human Exploration of the Moon and Mars.
- NASA. December 17, 1989. Advanced Space Analysis Office. Preliminary Assessment of Advanced Propulsion Mission Engine. Lewis Research Center.
- NASA. January 18, 1990. Aldrich, Arnold. Technology for the Exploration Initiative. Office of Aeronautics and Space Technology.
- NASA. January 18, 1990. Lenoir, Dr. W.B. Space Station Freedom Accommodation and Earth to Orbit Transportation Support of Human Exploration Initiative. Office of Space Station.
- NASA. January 1990. Nicogossian, Arnauld E., M.D. Human Exploration Initiative—Meeting Human Needs in Space. Office of Space Science and Applications.
- NASA. January 18, 1990. Peach, L.L., Jr. Human Exploration Initiative: Requirements for Space Station, Provided to the National Research Council Committee on the Human Exploration of Space. Office of Space Station.
- NASA. January 18, 1990. Reck, Gregory M. Space Nuclear Power & Propulsion Technology, Presentation to National Research Council. Office of Aeronautics and Space Technology.
- NASA. Truly, Richard H. Space Shuttle: The Journey Continues. NASA SP-117.
- National Commission on Space. 1986. Pioneering the Space Frontier. Bantam Books, Inc., New York.
- National Council on Radiation Protection and Measurements. July 31, 1989. Guidance on Radiation Received in Space Activities. NCRP Report #98.
- National Research Council (NRC). 1966. Space Science Board. Biology and the Exploration of Mars. Publication 1296. National Academy Press, Washington, D.C.
- NRC. 1978. Space Science Board. Recommendations on Quarantine Policy for Mars, Jupiter, Saturn, Uranus, Neptune, and Titan.
- NRC. October 1986. Committee on NASA Scientific and Technological Program Reviews. Post-Challenger Assessment of Space Shuttle Flight Rates and Utilization. National Academy Press, Washington, D.C.
- NRC. 1987. Committee on Advanced Space Technology. Space Technology to Meet Future Needs. National Academy Press, Washington, D.C.
- NRC. September 1987. Committee on Space Station. Report of the Committee on the Space Station. National Academy Press, Washington, D.C.
- NRC. 1987. Space Science Board. A Strategy for Space Biology and Medical Science. National Academy Press, Washington, D.C.
- National Space Council. 1969. Report on the Post-Apollo Space Program.
- O'Neill, Gerald K., and G.E. Maryniak. Space Studies Institute. Trends in Nonterrestrial Resource Development.
- Paine, Thomas O. October 1989. The Next Forty Years in Space. The 19th Invited I.A.F. Lecture.
- Pivrotto, D., T. Penn, and W. Dias. January 1989. Mars Rover 1988 Concepts. AIAA-89-0419.
- Rechtin, Eberhardt. January 1990. An Architects Perspective on Going to the Moon and Mars. Presented to the National Research Council Committee on Human Exploration of Space.
- Ride, Sally K. August 1987. Leadership and America's Future in Space. Report to the Administrator.

- Rosen, Robert, and R.J. Richmond. 1989. Earth-to-Orbit Propulsion for the 21st Century. IAF, 40th Congress, preprint IAF-89-302.
- Seamans, Robert C., and F.I. Ordway. 1977. The Apollo Tradition: An Object Lesson for the Management of Large-Scale Technological Endeavors. *Interdisciplinary Science Reviews*, Vol. 2, No. 4.
- Thangavelu, Madhu. December 1989. MALEO: Modular Assembly in Low Earth Orbit: A Space Station Freedom Based Architecture for a Permanently Manned IOC Lunar Base. University of Southern California.
- Truly, Richard H. November 29, 1989. Exploration Initiative Briefing to the National Space Council's Blue Ribbon Panel.
- TRW Technical Report. March 28, 1964. Manned Mars Mission Study for NASA AMES Research Center.
- US Congress, Congressional Budget Office (CBO). May 1988. The NASA Program in the 1990's and Beyond.
- US Congress, Office of Technology Assessment. July 1988. Launch Options for the Future: Buyer's Guide. OTA-ISC-383. US Government Printing Office, Washington, D.C.
- von Braun, Wernher, and Willy Ley. 1956. The Exploration of Mars. Viking Press, New York.
- Wahlquist, Earl. January 18, 1990. Space Reactor Systems, Presentation to National Research Council Committee on the Human Exploration of Space. Office of Nuclear Energy, Department of Energy.
- White House. February 11, 1988. Fact Sheet—Presidential Directive on National Space Policy. White House Publications Office.
- White House. July 20, 1989. Remarks by the President at 20th Anniversary of Apollo Moon Landing, July 20, 1989. White House Publications Office.
- White House. November 1989. National Space Policy. White House Publications Office.
- Wilhelm, Peter. 1990. SEA Launch And Recovery (SEALAR). Naval Center for Space Technology.
- Wood, Charles A., and Lewis D. Ashwal. 1981. SNC Meteorites: Igneous Rocks from Mars? *Proceedings of Lunar Planetary Science*, Vol. 12B, pp. 1359-1375.
- Woodcock, Gordon R., and B. Sherwood. 1989. Engineering Aerobrakes for Exploration Missions. AIAA.
- Wright, I.P., M.M. Grady, and C.T. Pillinger. July 20, 1989. Organic Materials in a Martian Meteorite? *Nature*, Vol. 340, p. 220.
- Young, Richard S. January 18, 1990. CELSS, Controlled Ecological Life Support System.

Acronyms, Abbreviations, and Technical Terms

ALS	Advanced Launch System
ESA	European Space Agency
EVA	extra vehicular activity
g;l-g	gravity; equivalent to one times the acceleration of gravity
GNP	Gross National Product
HEI	Human Exploration Initiative
LEO	low Earth orbit
NASA	National Aeronautics and Space Administration
NASP	National Aerospace Plane
NRC	National Research Council
NSC	National Space Council
SEALAR	Sea Launch and Recovery vehicle
SSF	Space Station Freedom
SSME	Space Shuttle Main Engine
STS	Space Transportation System
aerobraking	Use of a planet's upper atmosphere as a brake to slow the entry of a spaceship, rather than braking by propulsive methods.
cross range capability	The maneuvering capability of a spacecraft in orbit as well as after reentering the Earth's atmosphere. The shuttle, for example, has reasonably good cross range capability, due largely

	to having wings, while the reentry capsules employed in the early US space program had little maneuverability and were dependent on the trajectory of their orbit.
cryogenic fuels	Fuels stored at very low temperatures to maximize the energy density per unit volume of storage capacity. The fuels typically are gases at room temperature, but are stored at temperatures at which they are liquids.
specific impulse	The measure of an engine's efficiency; the ratio of pounds of thrust produced per pounds of fuel flowing through the engine each second.

Appendixes

Appendix A



THE VICE PRESIDENT
WASHINGTON

December 4, 1989

Dear Dr. Press:

As you know, President Bush charted a bold new course for the U.S. space program when he proposed on July 20, 1989, a long-range, continuing commitment to manned exploration -- first, to complete Space Station Freedom, to return permanently to the Moon, and then explore the planet Mars. At that time he also asked me, as Chairman, to lead the National Space Council in determining the necessary resources and timetables, and the feasibility of international cooperation for meeting these goals. It will take time to examine these complex issues completely, assess alternative approaches, and build the consensus necessary to proceed. The National Research Council represents a vital national resource in this process and I would like to solicit your help.

To respond to the President's tasking, the Council now has several analyses underway. The key ones are, first, an assessment of the approaches that might be taken to the program design, and how the variables of technology development, schedule, and cost can shape that design. The second is an assessment of the approaches to international cooperation -- what types of participation might be invited by the U.S. government, and what the implications of each type might be. Lastly, the Council will assess approaches to management -- what types of structures and functions will be required to manage this complex, long-term program.

A NASA team, led by Johnson Space Center Director Aaron Cohen, has submitted a report to NASA Administrator Richard Truly which was commissioned by Admiral Truly after the President's July 20 speech. Its purpose is to provide a database for the Space Council to refer to as it considers strategic planning issues.

Among other things, the NASA report describes five notional mission approaches to the Moon/Mars Initiative. The five approaches are not exhaustive, but rather a starting point for future studies and analyses. They do not represent decision options for the President, but rather reference cases. The Space Council intends to examine the approaches described in the report, as well as a range of robust technical alternatives and approaches to mission planning.

At a recent Space Council meeting, it was agreed that a review of the NASA report by the National Research Council would be most valuable.

It would be most helpful if, in its review, the National Research Council addressed the following questions. In considering these questions, we encourage your consideration of alternative approaches and other options, or range of options, for the human exploration concept. NASA will continue to seek alternative approaches to this initiative; we would appreciate National Research Council assistance in examining them as they become available.

Scope of the Report,

1. Does the report address the widest possible range of technically credible approaches to meeting the President's exploration goals? If not, what additional areas warrant exploration?
2. Over the course of the next thirty years, much technical progress will be made. What are the likely areas for technical breakthroughs relevant to space exploration? Has the report fully taken these into account?
3. Is the range of science goals and objectives commensurate with the proposed technical capability? Does the report distinguish between critical or enabling science and complementary science?
4. Are there implications (infrastructure-institutional/other national interest) that have not been considered?

Content,

1. What are the report's technical assumptions? Are they reasonable?
2. Are there innovative uses of existing technology which the report has overlooked?
3. Are the cost estimates and schedule assumptions reasonable? Are there alternate ways which the schedule might be moved forward to provide visible, near-term accomplishments? Similarly, are there alternate routes which could dramatically increase performance, lower costs, move the overall schedule forward, or reduce risk? If so, what levels of programmatic and technical risk do they have?
4. Are the overall approaches/architectures described in the report reasonable? For example, are the key elements of NASA's plan consistent? i.e. availability of the Space Station, heavy lift vehicles, etc.?

To meet our schedule of deliberations on the initiative, it would be useful to have your responses by February 28, 1990.

I expect that this review will be only the first of many interactions with the National Research Council on the various aspects of the initiative. I understand that both the Space Studies Board and the Aeronautics and Space Engineering Board have begun to examine the general question of manned space exploration. In addition, the Committee on Space Policy looked into management issues in their 1988 report. Further reviews in this area may be warranted over the next year. Clearly these will be continuing studies. Any comments you might have on the NASA concept will of course be understood to not represent a position of the National Research Council or its Boards on the value of or Administration approach to space exploration.

Sincerely,



Dan Quayle

Dr. Frank Press, Chairman
National Research Council
2101 Constitution Avenue, N.W.
Washington, DC 20418

NATIONAL RESEARCH COUNCIL

2101 CONSTITUTION AVENUE WASHINGTON, D. C. 20418

OFFICE OF THE CHAIRMAN

December 26, 1989

The Honorable Dan Quayle
Vice President of the United States
Office of the Vice President of the United States
Old Executive Office Building
Washington, DC 20501

Dear Mr. Vice President:

The National Research Council is pleased to accept your request that it undertake a review of the NASA "Report of the 90-Day Study on Human Exploration of the Moon and Mars." We are working hard to fill your need to have our report by February 28th; and have already made considerable progress in constituting the committee.

The Governing Board of the National Research Council, as well as those to be directly involved in the task, understand its importance and complexity, and the inherent limitations imposed by a very demanding schedule. In that light, while we look forward to performing this task, we concur wholeheartedly with your letter, which notes that this study is necessarily a circumscribed examination of the general question of human space exploration, that this study is only the first of what must be a larger examination of the question, and that, therefore, this initial work should not be interpreted as an endorsement by the NRC of any particular approaches to human space exploration.

Our review will comment on the technological feasibility of the options provided in the report, and will to the extent possible consider alternative approaches. The latter will again be limited by the time and information available to us, and therefore our consideration of alternative approaches cannot be inclusive.

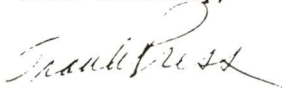
Of course, in the final analysis, the nation's program in human exploration, including the applicable technology, will be shaped by concern about the health of the crew on long space missions and by its purposes, of which a fundamental one is scientific exploration. This latter purpose accords with the goal of the U.S. civil space program "to expand knowledge of the Earth, its environment, the solar system, and the universe." The logistics of the mission cannot be uncoupled from those scientific purposes. Therefore, we are in complete agreement with your injunction that examination of a program of human space exploration must consider whether the range of scientific goals

The Honorable Dan Quayle
Vice President of the United States
December 26, 1989
Page 2

and objectives is commensurate with the proposed technical capability. Indeed, the institution already has underway explicit examinations of the scientific issues associated with human space exploration. We will be pleased to keep you apprised of this work as it proceeds.

Again, we are pleased to accept this task and are most appreciative of your confidence in the work of this institution.

Yours sincerely,

A handwritten signature in dark ink, appearing to read "Frank Press", with a stylized flourish at the end.

Frank Press
Chairman

bc: Robert M. White
Joann Clayton
David Bodde
Myron Uman
Richard Hart
Dean Kastel
Louis Lanzerotti

Appendix B

List of Participants

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION REPRESENTATIVES

- Admiral Richard H. Truly (Ret.), Administrator
- Mr. Arnold D. Aldrich, Associate Administrator, Office of Aeronautics and Space Technology
- Mr. Joseph Alexander, Assistant Associate Administrator, Office of Space Science and Applications
- Mr. Darrell R. Branscome, Director, Advanced Systems Development, Office of Space Flight
- Mr. Aaron W. Cohen, Director, Johnson Space Center
- Ms. Lana M. Couch, Director for Space (Act.), Office of Aeronautics and Space Technology
- Mr. Mark W. Craig, Director, Lunar and Mars Exploration Office, Johnson Space Center
- Dr. Leonard A. Fisk, Associate Administrator, Office of Space Science and Applications
- Dr. Leonard A. Harris, Chief Engineer, Office of Aeronautics and Space Technology
- Mr. Richard H. Kohrs, Director, Space Station Freedom Program, Office of Space Station
- Dr. William B. Lenoir, Associate Administrator, Office of Space Flight

Mr. John C. Mankins, Pathfinder Program Manager (Act.), Office of Aeronautics and Space Technology
Dr. Franklin D. Martin, Assistant Administrator for Exploration
Dr. Albert R. Miller, Assistant Associate Administrator, Office of Space Operations
Dr. Arnauld E. Nicogossian, M.D., Director, Life Sciences Division, Office of Space Science and Applications
Dr. Douglas A. O'Handley, Deputy Assistant Administrator, Office of Exploration
Mr. Lewis L. Peach, Jr., Deputy Director, Strategic Plans and Programs Division, Office of Space Station
Mr. Gregory M. Reck, Director, Mars Initiative Technology Team, Office of Aeronautics and Space Technology
Dr. John R. Rummell, Program Manager, Exobiology, Office of Space Science and Applications
Dr. Frank Sulzman, Chief, Space Medicine and Biology Branch, Life Sciences Division, Office of Space Science and Applications

OTHER BRIEFERS AND GUESTS

Dr. Mark Albrecht, Director, National Space Council (NSC)
Mr. Ivan Bekey, NSC
Dr. Timothy Coffey, Director of Research, Naval Research Laboratory
Dr. Michael J. Fry, Oak Ridge National Laboratory
Dr. Michael D. Griffin, Strategic Defense Initiative Organization
Lt. Gen. Harry Griffith (Army Ret.), Senior Vice President and Head of Washington Office, Brown & Root Co.
Lt. Gen. Richard C. Henry, Brown & Root Co.
Dr. Harry Holloway, M.D., Uniformed Services University of the Health Sciences
Mr. Maxwell W. Hunter, Consultant
Dr. Rod Hyde, Lawrence Livermore Laboratories
Dr. Yuki Ishikawa, Lawrence Livermore Laboratories
Dr. Harold Klein, Santa Clara University
Dr. Stephen J. Lanes, Department of Energy
Lt. Col. Roger Lenard, Department of Defense
Dr. Thomas O. Paine, Thomas Paine Associates
Dr. Harrison Schmitt, Consultant
Dr. Earl Wahlquist, Department of Energy
Dr. Peter Wilhelm, Naval Research Laboratory
Dr. Lowell Wood, Lawrence Livermore Laboratory, University of California
Col. Simon P. Worden, NSC

Dr. Richard Young, Vice President, Rockefeller University (Ret.)

NATIONAL RESEARCH COUNCIL

Dr. Frank Press, Chairman, National Research Council (NRC)

Dr. Robert M. White, President, National Academy of Engineering (NAE)

Mr. Philip M. Smith, Executive Officer, NRC

Mr. Edward J. Barlow, NRC Report Review Monitor

Dr. Alexander Flax, NAE Home Secretary

Dr. Richard L. Garwin, Fellow, IBM Thomas J. Watson Research Center

Dr. Richard C. Hart, Acting Associate Staff Director, Space Studies Board (SSB)

Mr. Dean P. Kastel, Director, SSB

Dr. Robert H. Korkegi, Director, Aeronautics and Space Engineering Board

Mr. Norman Metzger, Deputy Executive Officer, NRC

Dr. Myron F. Uman, Assistant Executive Officer for Special Projects, NRC

Appendix C

EXCERPTS FROM REMARKS BY THE PRESIDENT AT THE 20TH ANNIVERSARY OF THE APOLLO MOON LANDING JULY 20, 1989

... And space is the inescapable challenge to all the advanced nations of the Earth. And there's little question that, in the 21st century, humans will again leave their home planet for voyages of discovery and exploration. What was once improbable is now inevitable.

The time has come to look beyond brief encounters. We must commit ourselves anew to a sustained program of manned exploration of the solar system—and yes—the permanent settlement of space. We must commit ourselves to a future where Americans and citizens of all nations will live and work in space. ... And our goal is nothing less than to establish the United States as the preeminent spacefaring nation.

... Today we don't have a crisis. We have an opportunity.

To seize this opportunity, I'm not proposing a 10-year plan like Apollo. I'm proposing a long-range, continuing commitment.

First, for the coming decade—for the 1990's—Space Station Freedom—our critical next step in all our space endeavors.

And next—for the new century—back to the Moon. Back to the future. And this time, back to stay.

And then—a journey into tomorrow—a journey to another planet—a manned mission to Mars.

Each mission should—and will lay the groundwork for the next.

. . . And today I'm asking my right hand man, our able Vice President, Dan Quayle, to lead the National Space Council in determining specifically what's needed for the next round of exploration—the necessary money, manpower, and material—the feasibility of international cooperation—and develop realistic timetables, milestones along the way. The Space Council will report back to me as soon as possible with concrete recommendations to chart a new and continuing course to the Moon and Mars and beyond.

**EXCERPTS FROM THE NATIONAL SPACE POLICY
(EMPHASES ADDED)
NOVEMBER 2, 1989**

. . . The overall goals of the United States space activities are: (1) to strengthen the security of the United States; (2) to obtain scientific, technological and economic benefits for the general population and to improve the quality of life on Earth through space-related activities; (3) to encourage continuing United States private-sector investment in space and related activities; (4) to promote international cooperative activities taking into account United States national security, foreign policy, scientific, and economic interests; (5) to cooperate with other nations in maintaining the freedom of space for all activities that enhance the security and welfare of mankind; and *as a long-range goal, (6) to expand human presence and activity beyond Earth orbit into the solar system.*

. . . The objectives of the United States civil space activities shall be (1) to expand knowledge of the Earth, its environment, the solar system, and the universe; (2) to create new opportunities for use of the space environment through the conduct of appropriate research and experimentation in advanced technology and systems; (3) to develop space technology for civil applications and, wherever appropriate, make such technology available to the commercial sector; (4) to preserve the United States preeminence in critical aspects of space science, applications, technology, and manned space flight; (5) *to establish a permanently manned presence in space;* and (6) to engage in international cooperative efforts that further United States overall space goals.

CIVIL SPACE SECTOR GUIDELINES—Space Exploration

Human Exploration. To implement the long-range goal of expanding human presence and activity beyond Earth orbit into the solar system, NASA will continue the systematic development of technologies necessary to enable and support a range of future manned missions. This technology program (Pathfinder) will be oriented toward a Presidential decision on a focused program of manned exploration of the solar system.

Unmanned Exploration. NASA will continue to pursue a program of unmanned exploration where such exploration can most efficiently and effectively satisfy national space objectives by, among other things: achieving scientific objectives where human presence is undesirable or unnecessary; exploring realms where the risks or costs of life support are unacceptable; and providing data vital to support future manned missions.

Permanent Manned Presence. NASA will develop the Space Station to achieve permanently manned operational capability by the mid-1990s. Space Station Freedom will: (1) Contribute to United States preeminence in critical aspects of manned spaceflight; (2) provide support and stability to scientific and technological investigations; (3) provide early benefits, particularly in the materials and life sciences; (4) promote private sector experimentation preparatory to independent commercial activity; (5) allow evolution in keeping with the needs of Station users and the long-term goals of the United States; (6) provide opportunities for commercial sector participation; and (7) contribute to the longer term goal of expanding human presence and activity beyond Earth orbit into the solar system.

Front cover: Galileo: one of eight major panels on bronze
front doors of National Academy of Sciences building.
Sculptor: Lee Lawrie. Date: 1924 Photograph: Shonna Valeska

NATIONAL SPACE COUNCIL
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20500
March 7, 1990

MEMORANDUM FOR MR. J. STAPLETON ROY
Executive Secretary
Department of State

MS. EMILY L. WALKER
Executive Secretary
Department of Treasury

COL GEORGE P. COLE, JR.
Executive Secretary
Department of Defense

MR. THOMAS MURRIN
Deputy Secretary
Department of Commerce

MS. RUTH KNOUSE
Director, Executive
Secretariat
Department of
Transportation

GOV. JOHN H. SUNUNU
Chief of Staff
to the President

MR. ROBERT MATHIAS
Executive Assistant
to the Secretary
Department of Energy

MR. GARY EDSON
Chief of Staff
U.S. Trade Representative

MR. G. PHILIP HUGHES
Executive Secretary
National Security Council

MR. FRANK HODSOLL
Associate Director
Office of Management
and Budget

DR. ALLAN BROMLEY
Director
Office of Science and
Technology Policy

BRIG GEN THOMAS WHITE
Executive Assistant
to the Chairman
Joint Chiefs of Staff

MS. JESSIE HARRIS
Executive Officer
National Aeronautics and
Space Administration

MR. H. LAWRENCE SANDALL
Executive Secretary
Central Intelligence
Agency

MRS. BARBARA STARR
Executive Secretary
Arms Control and
Disarmament Agency

SUBJECT: National Space Launch Strategy Review

The Vice President has requested that the Space Council undertake interagency reviews to develop space launch and commercial space strategies. The approved Terms of Reference (TOR) are attached. Two Working Groups of the National Space Council's Policy and Implementation Review Committee will perform these reviews. The working group chairman for the commercial review will be Courtney Stadd, and for the launch review, James Beale.

I request that each agency identify a primary and an alternate working group representative for each review and provide those names to Cynthia Chase at 395-6175 by March 14, 1990.



MARK J. ALBRECHT
Executive Secretary

Attachments

TAB A: Launch Review TOR
TAB B: Commercial Review TOR

March 7, 1990

TERMS OF REFERENCE

NATIONAL SPACE LAUNCH STRATEGY REVIEW

PURPOSE: To review implementation of the space launch provisions of United States National Space Policy and develop a comprehensive national space launch strategy for Space Council consideration.

BACKGROUND: The National Space Policy identifies access to space, sufficient to achieve all United States space goals as a key element of national space policy. It states that United States space transportation systems must provide a balanced, robust, and flexible capability with sufficient resiliency to allow continued operations despite failures in any single system. It further identifies the goals of United States space transportation policy as: (1) to achieve and maintain safe and reliable access to, transportation in, and return from, space; (2) to exploit the unique attributes of manned and unmanned launch and recovery systems; (3) to encourage to the maximum extent feasible, the development and use of United States private sector space transportation capabilities; and (4) to reduce the costs of space transportation and related services.

SCOPE: This strategy review will comprehensively address all aspects of United States civil, commercial and national security space launch activities and the facilities and infrastructure which supports them. It will be coordinated with a parallel National Space Council review of commercial space strategy.

METHODOLOGY: The review will be conducted in three phases. Phase 1 will focus on defining the current launch situation. It will:

- Describe current and planned launch capabilities (e.g. performance, capacity, adequacy of infrastructure support, resilience to launch failure, etc.)
- Identify space launch needs, separating: 1) firm requirements associated with continued operation of existing space programs and other funded programs, 2) projected needs for programs or missions which are under consideration but have not yet been approved / funded, 3) Commercial launch needs (as provided by the commercial space strategy review).

- Compare current and planned space launch capabilities with these space launch needs and identify mismatches, if any.
- Assess the extent to which space launch capabilities sized to provide assured access to space for all currently defined launch needs will result in a robust national infrastructure capable of providing affordable and available access to space. Determine if any additional capabilities should be provided in order to enable new, currently unplanned, applications and, if so, what capabilities and how should they be financed?

Phase 2 will identify and analyze alternative actions available to the USG to resolve mismatches and meet U.S. space launch objectives. These may include, but not be limited to:

- Additional policy guidance, if needed.
- Development and acquisition of new systems or infrastructure.
- Investments in research and technology including the government's role, if any, in development of technology for commercial application.
- Investments in advanced ("leapfrog") technologies which offer the potential of large improvements in cost, performance or reliability.
- Modifications to procedures which might reduce launch costs or increase launch capacity.

Phase 3 will assess various combinations of policy, procedure and investment actions, including, if appropriate, revisions to management structures or changes in the current assignment of space launch roles and missions, to meet U.S. space launch objectives. Results will be incorporated in comprehensive space launch strategy alternatives for Space Council consideration.

PROCESS: The review will be conducted under the guidance of the National Space Council's Policy Implementation Review Committee (PIRC), by an Ad Hoc interagency working group, chaired by a member of the Council staff. Sub-groups or task teams may be established, as required, by the working group chairman. The review will be coordinated with, and will support, a parallel National Space Council review of Commercial Space Strategy.

SCHEDULE: The review will be conducted in accordance with the following schedule:

March 1990, Begin review.

June 1990, Council review of phase 1

September 1990, Council review of phase 2

October 1990, Council review of phase 3

MARCH 7. 1990

TERMS OF REFERENCE
COMMERCIAL SPACE POLICY
IMPLEMENTATION STRATEGY REVIEW

PURPOSE:

To assess the status of the commercial space market, review the implementation of the commercial space provisions of U.S. National Space Policy and develop a comprehensive commercial space strategy for National Space Council consideration.

BACKGROUND:

In the National Space Policy, the overall commercial space goal is to encourage continuing U.S. private sector investment in space and related activities in accordance with the following principles: (1) The U.S. shall encourage and not preclude the commercial use and exploitation of space technologies for national economic benefit. These commercial activities must be consistent with national security interests, and international and domestic legal obligations; (2) the U.S. will, as a matter of policy, pursue its commercial space objectives without the use of direct Federal subsidies; and (3) the U.S. shall encourage other countries to engage in free and fair trade in commercial space goods and services.

The policy directive also states that the U.S. government: (1) shall not preclude or deter the continuing development of a separate non-government Commercial Space Sector; (2) shall not conduct activities with potential commercial applications that preclude or deter Commercial Space Sector activities except for national security or public safety reasons; (3) supervise and regulate commercial space sector activities only to the extent required by law, national security, international obligations and public safety; (4) shall purchase commercially available goods and services to the fullest extent feasible; (5) encourage, to the maximum extent feasible, the development and use of U.S. private sector space capabilities, including space transportation; and (6) encourage the development of commercial systems which image from space, competitive with or superior to, foreign operated civil or commercial systems.

The National Space Policy has implementing guidance on the several areas including, definition and utilization of commercially available goods and services, cooperative agreements

with the private sector that protect the commercial value of intellectual property, pricing of government-provided goods and services, access and reimbursement for use of government facilities, and identification or elimination of laws and regulations that unnecessarily impede commercial space activities.

ISSUES:

There are a broad range of key concerns associated with the emergence of the non-Governmental Commercial Space Sector. These concerns include, but are not limited to:

- o The nature and scope of international competition in commercial space and development of an appropriate response to foreign government assistance to their commercial space activities.
- o Free and fair trade in international commercial goods and services, particularly with regard to the entry of goods and services from non-market or centrally-controlled economies.
- o Interpretation of the policy definition of "commercial goods and services."
- o Government practices that inhibit the commercial development of space -- such as procurement and risk management.
- o Private sector role, investment, involvement, and risk sharing in agency programs such as Space Station, Mission to Planet Earth, and the Space Exploration Initiative, as well as in USG planning for future national space infrastructure and transportation needs.

SCOPE:

This strategy review is intended to assess the status of the commercial space market and develop a long-term comprehensive strategy to encourage continuing U.S. private sector investment in space and related activities consistent with the provisions of the National Space Policy. In cases where current implementation does not meet those objectives, alternative implementation strategies will be developed and evaluated for National Space Council consideration. This review will be coordinated with a parallel National Space Council review of National Space Launch Strategy.

METHODOLOGY:

The strategy review will be conducted in three phases.

Phase One - Characterize the Commercial Development of Space

- o Develop an operational definition of commercial space activities.
- o Characterize the markets for commercial space goods and services in terms of: size of markets, amount of private investment, current and emerging space activities, barriers to entry, interaction with Government, and competitive environment -- including the role of governments in supporting their respective space industries.
- o Describe the U.S. Government implementation of National Space Policy to facilitate the commercial development of space.
 - Agencies will identify and describe specific activities, including inter-sector coordination, that implement or are aimed at future implementation of the National Space Policy. Relevant programs include, but are not limited to -- research and development, regulatory, procurement practices, international trade agreements, risk management, use of Government facilities.
- o Identify mismatches between the commercial space provisions of the National Space Policy and agency implementation of those provisions. This assessment will include, but not be limited to review of the following:
 - o Agency implementation of free and fair trade policy objectives including the status of international consultations on launch services (PRC, Europe).
 - o Procurement and regulatory policy and practices, including commercial space transportation.
 - o Commercial access to government resources including transportation, facilities, intellectual property, research and development, and reimbursement.
 - o Private sector participation in agency programs and plans for the future.

Phase Two - Identify and analyze alternative actions available to the USG to resolve the identified mismatches and to facilitate commercial development of space.

Phase Three - Develop and compare various combinations of actions identified in Phase Two and provide comprehensive strategy alternatives for National Space Council consideration.

PROCESS:

The review will be conducted, under the guidance of the National Space Council's Policy Implementation Review Committee (PIRC), by an interagency working group, chaired by a member of the Council staff. Sub-groups or task teams may be established, as required, by the working group chairman. In conjunction with the working group, the chairman will determine the format of the various analyses generated by the working group's activities. The review will be coordinated with a parallel National Space Launch Strategy review.

SCHEDULE:

The review will be conducted in accordance with the following schedule:

March 1990, Review begins.

April 1990, Council review of Phase I

June 1990, Council review of Phase II

September 1990, Council review of Phase III

NATIONAL SPACE COUNCIL
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20500

February 21, 1990

MEMORANDUM FOR MR. J. STAPLETON ROY
Executive Secretary
Department of State

MR. G. PHILIP HUGHES
Executive Secretary
National Security Council

MS. EMILY L. WALKER
Executive Secretary
Department of Treasury

MR. FRANK HODSOLL
Associate Director
Office of Management
and Budget

COL GEORGE P. COLE, JR.
Executive Secretary
Department of Defense

DR. ALLAN BROMLEY
Director
Office of Science and
Technology Policy

MR. THOMAS MURRIN
Deputy Secretary
Department of Commerce

BRIG GEN THOMAS WHITE
Executive Assistant
to the Chairman
Joint Chiefs of Staff

MS. RUTH KNOUSE
Director, Executive
Secretariat
Department of
Transportation

MS. JESSIE HARRIS
Executive Officer
National Aeronautics and
Space Administration

GOV. JOHN H. SUNUNU
Chief of Staff
to the President

MR. H. LAWRENCE SANDALL
Executive Secretary
Central Intelligence
Agency

MR. ROBERT MATHIAS
Executive Assistant
to the Secretary
Department of Energy

SUBJECT: Presidential Decision on the Space Exploration Initiative

The President has approved the following policy for the Space Exploration Initiative program:

- o The Initiative will include both Lunar and Mars program elements.
- o The early program will focus on technology development with a search for new/innovative approaches and technology.

- o The program will include investment in high leverage innovative technologies with potential to make a major impact on cost, schedule, and/or performance.
- o The program will take at least several years defining two or more significantly different human space exploration reference architectures, while developing and demonstrating technology broad enough to support all; selection of a baseline program architecture will occur after that time.
- o The program will perform mission, concept, and system analysis studies in parallel with technology development.
- o The program will include robotic science missions.
- o By spurring research and development in high technology fields, the space program will help promote American economic leadership.
- o The program will require the efforts of several agencies. NASA will be the principal implementing agency. The Department of Defense and the Department of Energy will also have major roles in the conduct of technology development and concept definition. The National Space Council will coordinate the development of an implementation strategy for the Exploration Initiative by the three agencies. To facilitate coordination, the Department of Energy will be added as a formal member of the National Space Council.


MARK J. ALBRECHT
Executive Secretary

NATIONAL SPACE COUNCIL
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20500

February 20, 1990

MEMORANDUM FOR GOVERNOR SUMONU

FROM: MARK J. ALBRECHT

SUBJECT: Dinner at the Vice President's Residence, February 7, 1990

1. The Vice President has asked me to provide you with a brief summary of the dinner meeting regarding U.S. space policy held at his residence on February 7, 1990. In addition to the Vice President and Mrs. Quayle, Dick Darman and Bill Kristol, there were six prominent space experts in attendance:

Dr. Bruce Murray, former director of the Jet Propulsion Laboratory

Dr. Fred Seitz

Dr. Gerald O'Neil of the Space Studies Institute of Princeton

LtGen (ret) Bernard Schriever, former head of Air Force Systems Command and first project manager of the US ballistic missile program

Dr. Lou Lanzerotti, Chairman of the Space Studies Board of the National Research Council

Dr. Allan Puckett, former CEO of the Hughes Aircraft Corp

2. The Vice President provided a brief overview of the goals and objectives of the President's space program, an assessment of the role of the National Space Council in the formulation and execution of national space policy, and its role in the development of specific implementation strategies and general oversight of space programs. He invited comments from the outside experts.
3. Although each participant provided his own assessment of the efficacy and utility of the National Space Council to this point, there was general agreement with the observation of Bruce Murray, that the formation and early direction of the

Space Council was a significant and positive development in the U.S. space program. As he put it, "A year ago, I was resigned to the conclusion that the U.S. space program was destined for perpetual mediocrity. The Space Council has revived my belief that we can recapture our space leadership."

4. Murray and others hastened to add that, as promising a new start as the Bush administration has made, significant and formidable obstacles remain to be overcome in actualizing a revival of our space program. As he put it, "the glass is half full and half empty. The problem is the federal government is still not really organized to make real progress in space exploration happen." Each expert cited an aging and maladapted NASA bureaucracy as the most significant impediment to progress.
5. A discussion ensued on means for effecting change in the system. Darman observed that significant organizational change in the federal bureaucracy is difficult, time consuming, and risky in terms of actual program outcomes. His view was that all things being equal, it is preferable to accept and isolate certain extant inefficiencies in the system, and to focus on new initiatives as a means for more certain and swift program enhancement. This view was discussed and a general consensus emerged that the best strategy would be to focus on new initiatives, but that these new initiatives should specifically include an emphasis on new management approaches and new organizational arrangements. A specific proposal was made to mandate the formation of a Defense Advanced Research Projects Agency (DARPA)-type organization within NASA with ample resources, serious organizational clout, and a clear charter to seek innovative and creative technical solutions to space challenges.
6. There was a general agreement that "smaller, faster, cheaper" ways of conducting space missions, including Mission to Planet Earth, could be found. There was also considerable criticism of the past development and present state of both the Shuttle and Space Station Freedom, with some disagreement about how radical were the changes that needed to be made. There was considerable agreement that the Europeans and Japanese have been smarter in many aspects of their space program than we have been in the last fifteen years or so.
7. The Vice President initiated a discussion of garnering public support for a rejuvenated space program. Darman observed that the American people believed in exploring frontiers, but also had a strong preference for concrete results. He therefore concluded that a rejuvenated space program must demonstrate early and tangible benefits to the average citizen in order to enjoy significant popular

support. There was general agreement on the need for early benchmarks of progress and success that will be meaningful to the American people, and for the need to explain the space program in terms intelligible to the American people. For example, one could explain how space will contribute to key energy, environmental, or defense needs of the American people in the 21st century.

8. The Vice President specifically challenged the group to identify early, high profile projects that would fit into such an explanation. Dr. O'Neil offered two examples of space mining arguing that early resource development in space would dramatically alter the ability to exploit space energy sources here on earth. Bruce Murray offered several examples including robotic exploration of craters at the lunar poles for the existence of ice, mining of asteroids in near earth orbit, or utilizing the Soviet MIR space station for U.S. caliber medical research as near term efforts with potential high public interest. There was agreement that pursuit and execution of such options in a timely and cost efficient manner would require substantially different management approaches than would likely come from NASA.
 9. The Vice President closed the meeting by asking that the participants continue to come forward with near term proposals such as those offered by Murray and O'Neil.
- N.B. The Vice President has asked Bruce Murray to assemble a team to meet with him in California during the week of February 25th to add to and deepen the suggestions made at this dinner.

cc: Ed Rodgers