Originally Processed With FOIA(s): S

FOIA Number: S

FOIA MARKER

This is not a textual record. This is used as an administrative marker by the George Bush Presidential Library Staff.

Record Group/Collection:	George H.W. Bush Presidential Records
Collection/Office of Origin:	Speechwriting, White House Office of
Series:	Speech File Backup Files
Subseries:	Chron Files, 1989-1993

OA/ID Number:	13795
Folder ID Number:	13795-003

Folder Title:
Young Astronauts Council 1/24/92 [OA 7567] [2]

Stack:	Row:	Section:	Shelf:	Position:
G	26	22	2	6

Young Astronaut Council

ROUGH IDEAS
FOR THE PRESIDENTS REMARKS

- This event kicks-off International Space Year (ISY), a year long celebration of our achievements in Space.

- It gives us an opportunity to focus on not only the benefits of space exploration, but the incredible laboratory that Space exploration offers for learning.

- Eight years ago, the Young Astronaut Program was conceived (downstairs in this building) to ignite young peoples interest in math, science and technology, using the excitement of Space. It was launched by President Reagan in the Rose Garden on October 17, 1984.

- Today, it is the world's largest space-related educational organization, with over 27,000 teachers and One Million students world-wide. There are Young Astronaut Chapters in every state of America and in some 42 nations around the world.

- On April 18, 1991, I announced my America 2000 educational strategy designed to make America first in the world in science and math achievement.

- Consistent with the America 2000 concept, the Young Astronaut Program honors local control and relies on local initiative. The Young Astronaut Council in Washington sets the standard, but allows flexibility to adapt the Program to the needs of the particular community or classroom.

- The Program recognizes that community by community and school by school, parents, teachers and officials know what is best for their students, and they have the will to do it.

- The Program looks beyond the classroom and recognizes that schools cannot do the job alone. The Program and its teachers rely on the assistance of parents, community leaders, businesses, civic organizations, the PTA and caring volunteers at the local level.

- The Young Astronaut Council shares the vision of the America 2000 strategy, that all children should start school ready to learn. To help achieve this end, the Council has created a special pre-school enrichment curriculum which includes both classroom and family activities emphasizing age-appropriate language, math, science, art, nutrition and health concepts.

- The Council believes that every school should be free of drugs and created special packages for students which emphasize the dangers of drug abuse as a significant barrier to achievement in school and in life.

- The Young Astronaut Program is designed not just for the extraordinary child, but the ordinary child. The Program is dedicated to the principle that all children can learn if the subjects are presented to them in a stimulating and exciting manner.

- In my opinion, the Council represents the type of educational organization that is making a difference with America's children.

- The Council recognizes the private sector as a vital partner. I would like to commend McDonald's Corporation and the Ronald McDonald's Children's Charities for making possible the exciting "Exploration and Discovery" Curriculum package that each of you have, celebrating ISY.

- Appropriately, its cover and the limited edition poster that each of you will receive depicts the Engines igniting as the Spacecraft leaves Earth's orbit and heads for Mars. This is not just a dream. We are planning that mission by the year 2019, and I expect that many Young Astronauts today will make routine visits to MARS in the 21st century.

Young Astronaut Council • 1211 Connecticut Avenue, N.W., Suite 800 • Washington, D.C. 20036 • (202)682-1984

FOR IMMEDIATE RELEASE
MARCH 11, 1991

YOUNG ASTRONAUT COUNCIL AWARDED NATIONAL SCIENCE FOUNDATION GRANT

WASHINGTON, D.C. - The Young Astronaut Council has been awarded a one million dollar grant by the National Science Foundation (NSF) to develop a two-year, comprehensive and school-wide model program designed to stimulate a science-based learning environment at two Washington, D.C. elementary schools. The entire faculties, student bodies, and school communities will be involved in the project. This initiative involves the development and use of creative, high-quality science and math-based curriculum materials, teacher kits, teacher training and supplemental activities which can be integrated into all subject areas.

"We are confident that this project will contribute significantly to the quality of science education," said Dr. Gerhard Salinger, NSF Program Director, Instructional Materials Development.

A team of recognized educational specialists will develop the curriculum materials and activities. Parents and community representatives will be encouraged to participate to reinforce the practicality and importance of what is being taught. The project will be evaluated by the Johns Hopkins University Center for Research on Effective Schooling for the Disadvantaged.

"Our experience with the Young Astronaut Program in urban schools has shown that a hands-on, space-focused curriculum can be very effective," said Council President, T. Wendell Butler. "We are grateful to NSF for its recognition of our achievements by providing the funds for this project to address what we believe is a critical need. Once the pilot program proves effective, we hope to take it to urban schools nationwide."

The program will be pilot-tested in two Space Magnet Schools - Houston Elementary and Park View Elementary - beginning in September 1991.

The Young Astronaut Council is a non-profit, national educational organization designed to encourage greater interest and skills in math, science and technology among children aged 6-16. More than 26,000 Chapters have been formed in all 50 states and in 35 foreign countries, reaching over 600,000 children. In 1989, the Council was recognized by the Harvard Business School as an exemplary non-profit organization in its textbook on "Entrepreneurship, Creativity and Organization".

For further information contact: Brenda King (202) 682-1984

PAul Burke: 682-1984

Young Astronaut Council • 1211 Connecticut Avenue, N.W., Suite 800 • Washington, D.C. 20036 • (202)682-1984

January 15, 1992

Note to Jim Schaeffer

Thank you for the meeting yesterday. We are excited about the January 24th event. As promised, I have enclosed

- o A proposed invitation list;
- o A suggested agenda;
- o Rough ideas for the Presidents remarks; and
- o Additional background information on the Young Astronaut Program.

Robert McCall, the NASA commissioned space artist, has agreed to allow Young Astronauts to present the original of his painting, "Mission To Mars, The Journey Begins", to the President. He would be pleased if there were some indication that this original piece (approximately 20" X 36") would be displayed either in the White House or one of the Smithsonian organizations.

Please let me know if I can be of any further assistance.

Sincerely,

T. Wendell Butler

T. Wendell Butler
President

cc: Joe Duggan ✓
Elizabeth Prestridge

(Duggan/Gershowitz)
January 16, 1992
Draft Two
Astro

PRESIDENTIAL REMARKS: YOUNG ASTRONAUTS COUNCIL
ROOM 450, OEOB
FRIDAY, JANUARY 24, 1992
[time]

[Acknowledgments]

I'm delighted to be with so many girls and boys -- from [Kindergarten through 9th Grade] -- in the Young Astronauts Council. I want to thank your parents and teachers and other supporters of the Young Astronauts Council for all you've done to bring us together today.

is this the age group?

Space exploration takes a long time to prepare. We are planning space missions today that won't be launched until you are adults with children of your own. And in fact, as President, I've set a goal that involves you. My goal is for some American girls and boys who are in grade school today, to travel to Mars 20 or 30 years from now.

New travels in space will give us answers to some things children wonder about. \ And, I might add, adults who are truly wise wonder about these same things, too. \\

The other day I heard what one five-year-old wonders about. \ One of my staff members asked his five-year-old son if we should build new space ships and send people to the Moon again.

The little boy said, yes, of course we should. Then his father asked him, <u>why</u> should we send people to the Moon?

"That's easy," the little boy said. \ "It's to see if there's Martians." \\

Actually, the little boy got it just about right. As most of you Young Astronauts know, I've challenged Americans to go back to the Moon to stay, and then onward to Mars. Sending people back to the Moon is the first step in our plan to send people to explore Mars. *TRUE?* It takes only three days for men to travel to the Moon, but it may take almost a year to get to Mars. We need to give people more experience with living conditions on the Moon before we send them on a much longer journey to Mars.

Once we reach our goal of sending men and women to Mars, we can find out what that little boy was wondering about. We can see if there are any signs of life on Mars. We can see if it is possible for any plants or animals to live on Mars. We can look for clues on Mars *not only* about how the Earth developed, ~~and~~ *but* about ~~how~~ *the wellspring of* life *itself* ~~on Earth developed~~.

We can look for clues on Mars not only to teach us how Earth developed, but about the wellspring of life itself

We know already that such vital things as air and water can be manufactured on Mars. Many years from now, we may need to draw on these kinds of resources to sustain life on Earth.

Pushing forward into space already is helping us here and now. More and more of the new jobs for people of your parents' generation are being provided by commercial space programs. Revenues from American commercial space programs grew by 14 percent in 1991. This year they're projected to grow by 20 percent. The commercial space business has grown so far and so fast that it now takes in about as much money each year as all

Use the NASA's GAS Program, & What Speilberg Did At U. of Utah

"America 2000" — stress education

I think some elaboration might be needed: studying Math, Science, stress

the receipts at movie theaters in the United States. America now exports $1 billion a year in commercial space goods and services. Those exports alone translate into jobs for 20,000 Americans.

Real progress is happening almost faster than we can imagine. Navigation satellites that helped guide our troops in Desert Storm just a year ago now help hikers, fishermen, surveyors and motorists find their way. Personal navigation receivers now help us manage our forests and wetlands. They help speed the shipment of goods on our highways.

Just 10 years from now, the older boys and girls here will be finished with college -- some of you even finished with graduate school. When that day comes -- when you're ready to start careers and families -- it will be commonplace to find jobs in the commercial space industry.

It's up to your parents and grandparents -- and the Congressmen they elect -- to keep us on track for this promising future of space exploration and commercial space enterprises. To stress how important this is, I am announcing right now the details of the space program proposals that will be in the new Federal budget I'll send to Congress next week:

[Placeholder for details from Bob Grady -- expected to include new funds for the Space Station; the Space Exploration Initiative (SEI, the Moon-and-Mars project); and some upcoming new launches.]

For you to fulfill your dreams of space exploration when you become adults, your parents and grandparents will have to make a new public investment in our space programs right now. I'm asking Americans to make a far-sighted commitment -- one that looks dozens of years and millions of miles beyond the recession and the other things that tend to preoccupy us today. Nice image I like this!

And I'm challenging you boys and girls, too: \ Start your preparations for tomorrow's new age of space exploration right now. \\ Keep that pledge you've made in joining the Young Astronauts Council. Make yourselves better and better students of math and science. Make the United States of America the leading country in the world in early education for math and science. Make your families proud. Make your teachers proud. Give it all you've got. \\

In doing this, you'll not only help our space program. You'll also help us meet the demanding goal I've set for our schools. With leadership from Secretary Lamar Alexander, who is here with us today, we're pursuing a strategy we call America 2000. It aims to involve parents more with our schools, and to revolutionize our schools with higher standards and better performance by start of the new century. Among the goals of America 2000 is to make America the world leader in math and science education.

If you share my dream of sending American men and women to explore Mars, if you share my dream of breaking through old boundaries to make our lives better, you'll see it will require time and effort and study and money. It's going to take teamwork. This will involve your parents and your grandparents right now. But most of all, for a long time to come, it's going to require your own best efforts. \\

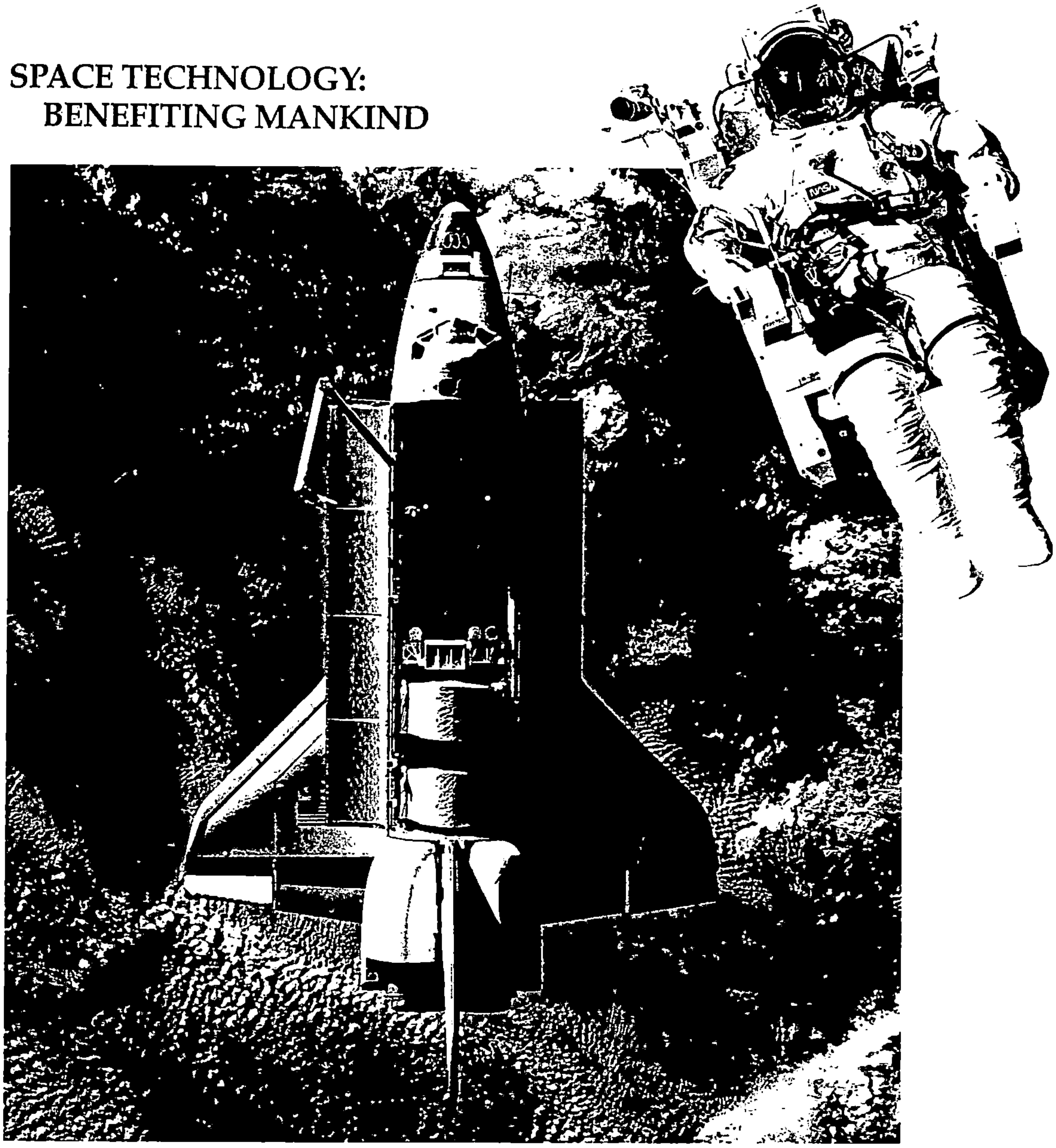
Now I take great pleasure in recognizing America's Young Astronaut Student of the Year. [Name to be provided] Congratulations. And our Young Astronaut Teacher of the Year. [name to be provided] Congratulations to you both, and keep up the good work.

Finally, I am pleased to accept on behalf of all Americans a piece of original artwork by Robert McCall. Robert McCall is a man of great imagination and talent. He's the artist responsible for those beautiful murals at the Air and Space Museum. This new painting is entitled, "Mission to Mars: The Journey Begins." Mr. McCall, thank you very much.

Thanks again to all of you. May God bless you, and may he help us fulfill our dreams for a better future for the United States.

# # #

SPACE TECHNOLOGY: BENEFITING MANKIND



An exciting curriculum package developed by the Young Astronaut Council and Rockwell International highlighting spin-offs from space exploration and discovery.

IV. SKILL AREAS (K-9)

Science
Observing
Measuring
Collecting data
Inferring
Predicting
Drawing conclusions
Identifying
Naming
Ordering
Comparing
Classifying
Experimenting
Hypothesizing
Using science equipment
Constructing models
Discovering

Social Studies
Spatial relationships
Directions
Symbols/coding
Community awareness
Global and space awareness
Discovery

Mathematics
Grouping
Measuring
Classifying
Ordering
Bar graphing
Using metrics
Line graphing
Applying rules
Discovering

Language Arts
Communication
Speaking
Writing
Reading
Vocabulary development
Following directions
Discovering

V. CONTENTS

October
I. Hydroponics—Soilless Growing
II. Moonsuits—A Cool Idea

November
I. Space Technology: Heart Monitoring
II. Optics: Using Light

December
I. Gravity
II. Down to Earth

 This learning packet was developed for the Young Astronaut Council by Julia A. Barra, Ph.D., Karyn Sotero and Genesta Guirty and illustrated by Henry Tubbs.

"Our space program . . . will revolutionize everything from computers to communication, from medicine to metals . . . it will create new technologies, new industries and new jobs."

President George Bush

SPACE TECHNOLOGY: BENEFITING MANKIND

I. INTRODUCTION

Space Technology: Benefiting Mankind is a Young Astronaut curriculum package designed to promote a better understanding and appreciation of space technology and its benefits to all mankind. What space scientists have developed for use in space has significantly improved the quality of our lives on Earth. This curriculum will allow Young Astronauts, through challenged-based activities, hands-on experiences and discovery techniques, to live in a "fantasy" environment of weightlessness—where luscious, leafy, green vegetables grow suspended in water (hydroponics), where thick liquid crystals respond to temperature changes by flashing colors of different hues, and where solid crystals formed free-standing are geometrically perfect, clear and pure.

Young Astronauts will discover holograms (three-dimensional images produced by lensless photography) and learn about beams of light that are used as ruler, knife and drill to magically perform medical feats of wonderment (lasers). In addition, Young Astronauts will become acquainted with the functioning of their own hearts and the functioning of the astronauts' hearts in space (the heart and circulatory functions).

II. INSTRUCTIONAL FRAMEWORK

This curriculum package was produced in three levels: Trainee (grades K-3), Pilot (grades 4-6) and Commander (grades 7-9). The subjects and concepts are used at all levels, but the activities are differentiated for varying age levels.

The activities are appropriate for integration and/or correlation with the science, mathematics, social studies and language arts curricula.

III. GOALS

Young Astronauts will

1. Identify ways in which space technology has benefited mankind.
2. Demonstrate, through challenge-based activities, some of the scientific principles associated with space technology.
3. Apply the scientific method in collecting data, interpreting previous information learned, hypothesizing and applying rules, analyzing and synthesizing/evaluating.
4. Better understand and appreciate space technology and its vital benefits to the inhabitants of planet Earth.

SOURCES AND RESOURCES

Some of the educational activities contained in this package are based on materials developed by NASA, other aerospace organizations, scientists and educators as indicated below. The texts cited below provide a broader examination of the various topics.

Atamian, G.C., and Steven J. Edberg. *Discover the Universe Learning Book*. Bushnell Light Fantastic Optical Set. Bausch and Lomb, 1988.

Barufalid, James, et al. *Heath Science*. D.C. Heath and Co., 1985.

Beauchamp, Wilbur L., and Glen O. Blogh. *Science Is Experimenting*. Atlanta: Scott Foresman, 1962.

Bremmer, Dale. Aerospace Education Services Project, Oklahoma State University. "Zero-G Demonstrator."

Brook, Alan J. *The Living Planet*. Edinburg University Press, 1964.

Carle, Mark, et al. *Physical Science: The Challenge of Discovery*. Lexington, MA: D.C. Heath and Co., 1991.

Chemistry Can Be Fun, Laboratory Experience for Middle School Students. Summer 1986. Institute for Chemical Education. University of Maryland, College Park, MD.

Cooney, Timothy M., et al. *Earth Science*. Glenview, IL: Scott Foresman Publishers, 1990.

Gardner, Robert. *Projects in Space Science*. New York: Simon and Shuster.

Growing Ideas: A Journal of Garden-Based Learning. Burlington, VT, 1991.

Haggerty, James J. *Spinoff 1990*. NASA Office of Commercial Programs, Technology Utilization Division.

Heimler, Charles, and Charles Neal. *Principles of Science*. Merrill Publishing Co., 1975.

Jet Propulsion Laboratory Education Outreach Program: Comfortable Approach to Teaching Science Project 1989, 1991.

Kinney, William. *Medical Science and Space Travel*.

Lynch, Nancy Coggins. *Hands On Biology*, "Activities of Elementary Schools." Annapolis, MD: Appha Publishing Co., Inc., 1989.

Mason, Robert G., ed. *Life: In Space*. Boston, Little, Brown and Co. (Time-Life Books, Inc.), 1983.

Otto, James, et al. *Super Science*, 1991.

Science Weekly. C. Mayberry, Editor. Science Weekly, Inc., 1991.

Science Year 1991. World Book, Inc.

Shaplant, David, and Michael Roycoft. *Spacelab, Research in Earth Orbit*. Cambridge, 1984.

Skelsey, Alice, and Gloria Huckaby. *Growing Up Green*. New York: Workman Publishing Co., 1974.

Vogt, Gregory. Aerospace Education Services Project, Oklahoma State University. "Vertical-G Meter."

Vogt, Gregory. Aviation and Space Education News. Oklahoma State University. "Weightlessness Demonstrator."

Young, Sandie. Jet Propulsion Laboratory: Comfortable Approach to Teaching Science Project, 1991. "Ice Cream in a Bag."

EPCOT Educational Media, 500 South Buena Vista St., Burbank, CA 91521 (Hydroponics).

Hydroponic Society of America, Box 6065, Concord, CA 94524.

For Dan from Joe
suggested abbreviation of Grady's material.

INSERT FOR YOUNG ASTRONAUTS SPEECH (1/24/92):

(Third paragraph, after "...civil space program."

~~One key element of that increase is~~ [This includes] full funding for Space Station Freedom ~~-- I will ask for~~ $2.25 billion, an increase of 11 percent over last year. ~~You know, this year, for the first time in many years, after a series of Congressionally-mandated redesigns,~~ Space Station is [back] on track and on schedule. Last year, we had an honest debate with those in the Congress who want to kill Space Station. We ~~pointed out~~ that Space Station Freedom is not only a~~n enormously~~ valuable ~~part of America's~~ *scientific* program in space, but it is essential to our *destiny* as a pioneering nation in space. ~~It is the logical next step in any sound program of space exploration.~~ We won that very tough vote in Congress last year. ~~Now is not the time to turn back on manned exploration of space. Now is not the time to turn back on Space Station Freedom.~~ [won because the American people agree]

I ~~understand that~~ [know] many are concerned about the balance between science and exploration in our space program. The budget I will propose next week will not short-change science. ~~It will contain funds for the Mars observer, a new X-Ray telescope, and our internationally-recognized global change research program -- with Mission to Planet Earth at its heart.~~ Space science will remain more than 23% of NASA's program, and will increase by 10% over the current year.

But America's destiny must include manned exploration -- so my budget ~~will include~~ increases funding for ~~the~~ technologies we will need to send man beyond earth's orbit. That includes propulsion technologies, life support technologies, and two new missions to explore the moon with robots so that man can return there to live and work. And finally, my budget will include a dramatic expansion of two exciting new programs that this Administration has begun -- $250 million for a New Launch System to give us the infrastructure for a new generation of space missions, and $80 million for the National Aerospace Plane, which may one day enable direct flights from earth to orbit.

(Note: these paragraphs can replace the rest of the existing paragraph on pp. 3-4 that ends with "...called Mars Observer.")

Office of Management and Budget
Energy and Science Division

202-395-4817 | Telecopier Numbers | 202-395-3165/1086

Date: 1/22/92

Please deliver to

Name: Joe Duggan

Agency: OC

Fax was sent from

Name: Norine Noonan

Phone number (voice): 3534

Total number of pages including this page: 2

Message: Per your request, here are some inserts for the Pres'. speech to the Young Astronauts Council. Please call if you have any questions. Thanks.

- New Launch System: I will propose $250 million for NASA and the Department of Defense to develop a new family of rockets that will help launch America into the 21st century. This funding is nearly 3 times what the Congress appropriated in 1992. The first flight of this new system is planned for 2002.

- Upcoming Space Launches: Space Shuttles will fly 8 times this year -- one was launched just this week with an exciting new laboratory aboard -- and 8 times in 1993. Shuttles will rescue a stranded communications satellite -- something only America can do -- and will carry the first commercially-developed space laboratory. Expendable rockets, supplied by American commercial launch companies -- will loft exciting missions such as Mars Observer (our first trip back to the Red Planet in many years), and Polar and Wind (to study our own Sun).

- Space Station Freedom: I will propose $2.25 billion for Space Station Freedom, an 11 percent increase over 1992. This will continue the excellent progress we have already made toward establishing a permanent manned presence in space for America. Freedom is the centerpiece of our space program and is the first step on the road to manned exploration of the planets.

- Space Exploration: I will propose $29 million for NASA to begin 2 new missions to explore the Moon so that Americans can live and work and learn there. We will also fund missions like Cassini, an unmanned mission to explore Saturn, and we will learn more about new technologies, such as nuclear powered spaceflight, that will bring manned exploration closer. I'm sure some of you will be on that first flight to another planet. Send me a postcard, won't you?

OMB

To Gary

Date Jan 17 '92 Time 3:55 p

WHILE YOU WERE OUT

M Jim Freck

of Department of Commerce

Phone 377 8125 (Space)

Area Code Number Extension

TELEPHONED		PLEASE CALL	
CALLED TO SEE YOU		WILL CALL AGAIN	
WANTS TO SEE YOU		URGENT	
RETURNED YOUR CALL			

Message

Jim Freck

At home: 703-644-6865

DC

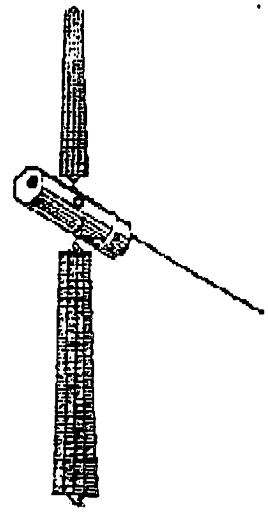
Operator

AMPAD EFFICIENCY® 23-021 CARBONLESS

DEPARTMENT OF COMMERCE • UNITED STATES OF AMERICA

OFFICE OF SPACE COMMERCE
U.S. DEPARTMENT OF COMMERCE
14th and Pennsylvania Ave., N.W., Room 7060
Washington, D.C. 20230

(202) 377-8125 -- voice
(202) 377-5173 -- fax



To: Joe Duggan Date: ____

____ Time: ____

Phone: ____ Fax: (202) 456-6218

From: Jim Frelk

Pages to Follow: 17

Notes/Instructions:

for Duggan
FAX 456-6218

Attachments:

Commentary on "Economic Growth and the Final Frontier"
Policy Statement on the Space Exploration Initiative
Press release on growth of space commerce

Things to look forward to in the next ten years:

Space technology plays a vital role in the security and well-being of our nation and play an increasingly important role in your future.

We depend on satellites to tell us what the weather will be tomorrow and next week. Communication satellites allow us to talk to almost any place in the world today. In the next ten years, it will be possible to make phone calls from anywhere in the world - because you'll be able to carry the phone in your pocket and talk directly to a satellite overhead.

The navigation satellites that helped guide our troops in Desert Storm today guide hikers, fishermen, surveyors, and motorists. Small, personal navigation receivers are helping to make maps more accurate, manage our forests and wetlands, and speed the shipment of goods on our nation's highways.

The International Space Station will be under construction less than 200 miles above us - the first stopping point on our way to the stars. Americans - like you - will be working with scientists and engineers from many countries to learn to live, work, and I dare say, even play, in space. They will be testing the technologies necessary for us to return to the Moon, this time to stay. And then journey farther into the Solar System.

If you want to be part of this great adventure, you will need to study hard, work hard, and above all, continue to keep in your hearts the curiosity and drive of the explorers and settlers who came to America not so very long ago.

The Soviet Union in space:

The Soviet Union was a great pioneer in space. Your parents may remember what a great shock it was to learn that the first satellite circling the globe came from the Soviet Union - and not the United States.

Today, the Soviet Union is no more and the Commonwealth of Independent States and the other republic of the former Soviet empire are struggling to find their place in the world. Just as space was important to the old Soviet Union, I believe it can play an important role in the creation of a market economy in the Russian republic.

The National Space Council, led by Vice President Quayle, has been working with U.S. government agencies and industry to explore opportunities for using Soviet space technologies. In looking to the future of Russia in space, I believe it is important that we encourage people-to-people contacts, industry to industry, and not try an replace Soviet central planners with U.S. central planners, no matter how well-intentioned. It is my hope that we will be able to work with these new Commonwealth republics to use the impressive space capabilities they have inherited to forge a new path - one of peaceful international cooperation, scientific discovery, and economic growth.

Economic Growth and the Final Frontier

The U.S. Department of Commerce has released 1992 forecasts for 350 U.S. industries indicating moderate growth for many of them, with both the manufacturing and service sectors contributing to a continuing recovery in the coming year. In particular, exports will continue to make substantial contributions to the economy and be of particular importance to high growth industries. Among these forecasts, one sector was especially notable - space commerce. Moving out of both the realms of science fiction and unrealistic expectations, the private commercial space industry is small, growing, and most importantly, being driven by commercial forces and not government spending. In satellites alone, U.S. industry is looking to foreign sales of about $1 billion - or the equivalent of 100,000 imported cars.

This growth in commercial space activities is occurring, surprisingly, in the face of slower demand for most aerospace products due to reduced defense contracts. Space commerce in the United States is expected to generate revenues of about $4.7 billion in 1992 - or roughly equal to U.S. movie theater receipts. The growth rate for 1992 is particularly impressive at 20% per year. Even in 1991, during which the GNP grew at under 1%, commercial space revenues grew at 14%.

The rapid growth in space commerce, which has been consistently ahead of general growth rates for the past four years, is being sustained by a number of revolutionary new products and services. Satellite-fed Global Positioning System (GPS) receivers (which provided precise navigation information to our armed forces during Desert Storm) are being increasingly used by to surveyors, boaters, traffic planners and aviators. Some Japanese car makers even offer GPS receivers and compact disc-based street maps to help lost drivers.

Demand for remote sensing satellite data is also increasing as analyses enable oil exploration, crop management and real estate development firms to become more efficient and thus more competitive. It is particularly interesting, as a Californian, to learn how images from space can be combined with navigation data to make the agricultural use of water, fertilizer, and pesticides dramatically more efficient. This particular application of space technology, "precision farming," is likely to play a significant role in the future of the nation's $300 billion agriculture business.

Satellites and launch vehicles have joined aircraft and machine tools as important elements of our defense industrial base and there has been a growing realization that commercial growth has important benefits for national security in a time of shifting defense budgets. Space commerce also highlights the differing relations between government and industry around the world. As an emerging industry, some nations have protected and subsidized their firms, while others, like the United States, have sought to minimize direct government support and management of space industry.

For all space-faring nations, the exploration and exploitation of space started as a government-dominated activity. However, after the dramatic Apollo missions to the Moon and exploration of the planets, a more subtle and hopefully enduring space development has unfolded -- the growth of private space industry out of the shadow of governments. The United States led the way with commercial communications satellites in the 1960s and later with commercial launch services in the 1980s. Europe has quickly followed and Asian nations are showing an increasing interest in space markets.

In recent years, the U.S. government has made extra efforts to clear away the regulatory underbrush that has accumulated over the years and impeded the competitiveness of private space industry. These efforts have included removing the Space Shuttle as a competitor to private launch vehicles, allowing competition to the Intelsat communications monopoly and simplifying export regulations on space-related products (e.g., GPS receivers) to allow U.S. firms to compete overseas.

Another step has been in eliminating the barriers to technology transfer from federal labs to the private sector. For example, Strategic Defense Initiative (SDI) research over the past several years has resulted in dramatic reductions in the size, weight and cost of many spacecraft parts and private firms are interested in exploiting these advances in commercial satellites. Government-developed technologies, once transferred out of federal labs and research centers and into the private sector, can be applied to goods and services and continually improved in response to market forces.

As Chairman of the Competitiveness Council, the Vice President has worked to cut the economic burden of regulations and promote competition. As a member of the National Space Council, I am concerned about the remaining regulatory and market barriers acting as impediments to U.S. competitiveness in space commerce. Regulations, written for an era in which only governments sent out spacecraft, need to be reexamined for an era in which the public and private sectors share in the use of space. In many cases, U.S. restrictions are more burdensome than those faced by our European competitors.

Currently, we are seeking to reduce restrictions on the sale and distribution of remote sensing data from privately financed satellite systems. When a U.S. oil company and a major news organization asked the Commerce Department about getting licenses for operating private remote sensing satellites, they were told that regulations would require them to sell their data to anyone who asked - even foreign competitors. The requirement for "non-discriminatory" access may be reasonable for satellites paid for by public taxes, but not when financed by private capital.

Beyond getting out of the way, the U.S. Government has a limited but important role to play in encouraging a competitive space industry. We need to ensure that U.S. firms are treated fairly in international competitions and that governments minimize actions that distort or disrupt commercial markets. To that end, the Office of the U.S. Trade Representative is leading talks with the European Space Agency on "rules of the road" for commercial launch services. If we can reach an agreement this year, then it will be possible to include other space-faring nations, such as Japan, in a common framework for fair competition.

Trade rules are not enough, however, to succeed in international markets. As in any other business, the U.S. space industry needs superior, high-quality products to compete. Government projects like the National Aerospace Plane and Single-Stage-to-Orbit are important to developing new, advanced space systems that meet vital government needs and which (through technology transfer) hold the promise of assisting the private sector develop new products.

In order to succeed in the harsh physical environment of space, U.S. industry has had to navigate a complex government environment on Earth. The growth of space commerce driven by market forces is a healthy development for both the economy and government space efforts. In the end, a strong commercial space industry and steady government space efforts will benefit each other through cooperation and even a little creative tension. We are continually seeking a closer dialogue with industry to understand and consider their needs in policies, regulations, and international negotiations. Government benefits when it listens to those facing the discipline of international markets - on Earth or on the final frontier.

1180 words

December 10, 1991

National Space Policy Directive

Memorandum for: The Vice President
The Secretary of State
The Secretary of the Treasury
The Secretary of Defense
The Attorney General
The Secretary of Commerce
The Secretary of Transportation
The Secretary of Energy
The Director of Management and Budget
The Chief of Staff to the President
The Assistant to the President for Science And Technology
The Director of Central Intelligence
The Chairman of the Joint Chiefs of Staff
The Administrator of the National Aeronautics and Space Administration

Subject: Space Exploration Initiative

I. Introduction

I have approved the next in a series of steps to be taken by the National Aeronautics and Space Administration (NASA), the Department of Defense (DOD), the Department of Energy (DOE) and other federal agencies regarding the planning for and conduct of the nation's Space Exploration

Initiative (SEI) which includes both Lunar and Mars elements, manned and robotic missions and supporting technology. This series of steps augments previous Presidential directives and recognizes the recommendations of both the Advisory Committee on the Future of the U.S. Space Program and the SEI Synthesis Group. The exploration of space is one of the fundamental goals of the U.S. civil space program. The SEI objectives, which build upon previous accomplishments as well as upon existing programs, include a return to the moon - this time to stay - and human expeditions to Mars. In addition the objectives will provide a strategic framework for the conduct of the U.S. civil space program and will help focus investments in many areas of goal-oriented research and development by government, industry and academia. Consistent with the Commercial Space Policy, this framework is also intended to encourage private sector activities which augment or support the SEI objectives.

NASA is the principal implementing agency for the SEI. DOD and DOE, as participating agencies, will have major roles in support of the SEI in the conduct of technology development and concept definition. Other U.S. government agencies are encouraged to participate by developing activities supportive of the SEI.

II. Exploration Responsibilities & Actions

To establish a firm foundation and clear direction for the SEI, the following actions shall be undertaken immediately:

a. NASA shall establish an exploration office headed by the Associate Administrator for Exploration and staffed by NASA and representatives from other participating agencies. The Associate Administrator shall be responsible for architecture and mission studies, planning, and program execution, as well as the definition of resulting requirements for research, technology, infrastructure, mission elements and program implementation. As director of the exploration office, the Associate Administrator shall prepare an annual status report. The NASA Administrator shall present this report to the National Space Council.

b. Working with participating agencies, NASA's Associate Administrator for Exploration shall develop a strategic plan for the SEI to establish the basis for integrating existing and future SEI-related activities. This plan shall address research, technology development and operations and identify the relationships between the SEI mission elements and the U. S. space infrastructure.

c. A Steering Committee for Space Exploration shall be established, chaired by NASA's Associate Administrator for Exploration, and shall include representation from participating agencies. The Committee shall be the senior interagency forum for coordinating organizational interfaces, reports, plans and activities, and SEI-related programs and budgets; and for identifying those issues requiring consideration by the National Space Council. The Department of State shall participate in any meetings of the Committee related to international cooperation or other international activity.

III. Exploration Guidelines

To insure that necessary preparatory activities are accomplished, the following steps shall be taken:

a. The participating agencies shall address critical, long-lead research and technology development activities which are supportive of the exploration strategic plan.

b. The Department of Commerce and other appropriate agencies shall encourage the development of SEI-related proposals which foster private sector investments, ownership and operation of space-related projects and ventures as well as promote U.S. economic competitiveness. These agencies shall seek increased cooperation with the private sector through mechanisms such as technology transfer agreements, cooperative research and development agreements, and consortia, as appropriate.

c. Exploration requirements shall be incorporated into the evolutionary plans for the new national launch system.

d. NASA, DOD and DOE shall continue technology development for space nuclear power and propulsion while ensuring that these activities are performed in a safe and environmentally acceptable manner and consistent with existing laws and regulations and agency mission requirements.

e NASA and appropriate participating agencies shall implement a definitive life science program in support of the human exploration of the Moon and Mars.

f. All participating agencies should include space exploration in their respective educational programs. In addition, participating agencies shall take advantage of university research capabilities and cooperative education programs in SEI-related activities.

g. International cooperation in this endeavor is feasible and could offer significant benefits to the United States, subject to the satisfaction of national security, foreign policy, scientific and economic interests.

h. Expanding on individual agency efforts to improve and streamline acquisition procedures, the Associate Administrator for Exploration and participating agencies shall work with the Office of Management and Budget and the Office of Federal Procurement Policy to develop improved U. S. government procurement practices available for SEI acquisition.

i. The exploration office shall seek innovative ideas by encouraging input from all sectors of American society.

IV. Reporting Requirements

a. By November 1992, the first annual status report shall be presented to the National Space Council. It shall address options for exploration architectures and initial capabilities.

b. The initial version of the Strategic Plan for the Space Exploration Initiative shall be presented to the National Space Council by February, 1992, and updated regularly thereafter. The initial version shall focus on technology development and alternate mission architectures.

UNITED STATES DEPARTMENT OF
COMMERCE
NEWS
WASHINGTON, D.C. 20230

OFFICE OF THE SECRETARY
OFFICE OF SPACE COMMERCE

Contact: Mary Ann Fronce
(202) 377-8125

FOR IMMEDIATE RELEASE
Monday, Jan. 6, 1992

DEPARTMENT OF COMMERCE PREDICTS RAPID GROWTH OF SPACE COMMERCE IN 1992

The commercial space industry is projected to be one of the fastest growing sectors of the U.S. economy in 1992, according to economic data released today by the U.S. Department of Commerce. As part of its 1992 publication of the annual "U.S. Industrial Outlook," the Commerce Department estimated that space commerce will expand by 20% to $4.7 billion from 1991 revenues of $3.9 billion. Leading this expansion will be continued growth in satellite communication services, navigation products, and remote sensing data sales.

Commercial space revenues have consistently grown faster than the economy as a whole for the past four years and are now comparable to domestic movie theater receipts. In 1991, while the GNP grew at a rate of less than 1%, commercial space revenues grew 14%. The growth in commercial space activities is also occurring in the face of continued retrenchment in the U.S. aerospace industry. Revenues for the U.S. aerospace industry declined 4.2% in 1991 and are expected to decline 3.4% in 1992 due to decreasing defense spending and increasing international competition.

James Frelk, Director of the Office of Space Commerce at the Commerce Department, said "U.S. industries are seeking commercial opportunities in new private sector markets at home and overseas. The steady, healthy growth of commercial space revenues is a hopeful sign for the future of U.S. high-technology industries in a tough, competitive international market."

###

41

Space Commerce

In the commercial space sector, revenues are expected to increase about 20 percent to $4.7 billion in 1992 from $3.9 billion in 1991. The fastest growing industries are satellite communication services and remote sensing.

Space commerce consists of five major areas of space-related goods and services: commercial space launches, satellite communications, satellite remote sensing, materials research and processing in space, and space-based industrial R&D facilities. Although communications satellites have been owned and operated by private companies since 1964, commercial activity in the other areas began in the 1980's following new Government policies to privatize space activities. Space commerce industries do not have separate Standard Industrial Classification (SIC) codes.

Before reading this chapter, please see "How to Get the Most Out of This Book" on page 1. It will clarify questions you may have concerning data collection procedures, factors affecting trade data, forecasting methodology, the use of constant dollars, the difference between industry and product data, and sources and references. For other topics related to this chapter, see chapters 17 (Advanced Materials; Biotechnology, Advanced Ceramics), 21 (Aerospace: Missiles and Space Vehicles), 28 (Telecommunications Services) and 30 (Radio Communication and Detection Equipment).

Most revenues in space commerce are generated by satellite communications. After a slowdown in growth in 1991, because of a dip in the mature space markets (satellites and launches), revenues in the commercial space sector reflect the rapid growth in all sectors. Expanding markets include mobile services and equipment for vehicle tracking, navigation and positioning, and voice and data communications.

A new industry is emerging: space-based R&D facilities. A privately funded commercial R&D facility is now under construction to be flown by NASA on its Shuttle twice a year beginning in 1992. This experimental laboratory, known as Spacehab, contains facilities to be leased to companies for long-term research in protein crystals, metal alloys, pharmaceuticals, and other advanced materials.

The market for small launch vehicles and launch services depends on NASA and military contracts. The growing remote sensing industry, which markets raw data and images of the earth's surface, also continues to rely on Government support for building the Landsat satellites and providing funds for their operation.

Table 1: Estimates of U.S. Space Commerce Revenues

(In millions of dollars)

Industry	1988	1989	1990	1991[1]	1992[2]
Commercial satellites	590	900	1,000	800	1,000
Satellite services	600	750	800	1,200	1,350
Fixed	600	700	735	1,116	1,200
Mobile	0	50	65	85	150
Satellite ground equip.	600	790	860	1,300	1,700
Commercial launches (large capacity)	0	150	570	320	400
Remote Sensing Data and Services	60	115	140	170	200
Total	1,840	2,705	3,370	3,850	4,650

[1] Revised.
[2] Forecast.
SOURCES: U.S. Department of Commerce: International Trade Administration (ITA), Office of Telecommunications and Office of Aerospace; Economic and Statistics Administration, Office of Business Analysis.

INTERNATIONAL COMPETITIVENESS

Seven countries are currently capable of building and launching satellites: the United States, Japan, France (in cooperation with the European Space Agency, or ESA), U.S.S.R., China, India, and Israel.

The primary competitor for the U.S. commercial launch industry, which uses large capacity boosters (Delta, Atlas, and Titan) to launch communications satellites, is Arianespace, a French-led European launch company. The two countries dominate the world market. China launched a U.S.-built satellite in 1990, but a change in U.S. policy has suspended future launches due to concerns about transfer of missile technology.

In remote sensing, the major competitor to the two-satellite U.S. Landsat system, which has 55 percent of the world market, is SPOT Image, a French company that also has two satellites. SPOT Image is partly owned by Centre National d'Etudes Spatiales (CNES), the French space agency. India and Japan also have remote sensing satellites used for non-commercial purposes: India to monitor crops and monsoons, and Japan to study urban land use, oceans, and forests.

The U.S. satellite manufacturing industry competes for international communications satellites contracts with companies in four European nations (France, United Kingdom, Germany, and Italy), Japan, the U.S.S.R., and Canada. The U.S. has more than 60 percent of the world market and is also the acknowledged leader in developing new technology and new markets for mobile satellite services and for satellite navigation and tracking. Europe and Japan are developing mobile satellite communications systems based on U.S. and indigenous technologies.

Export earnings in the space commerce sector are expected to decrease from $800 million in 1991 to $560 million in 1992. Five communications satellites worth $500 million will be produced for other nations in 1992, the same as in 1991. The U.S. launch industry will generate about $60 million from launching one payload for the International Telecommunications Satellite Organization (INTELSAT).

Outlook for 1992

Combined revenues from all aspects of the commercial space industries are expected to reach $4.7 billion, an increase of more than 20 percent from the $3.9 billion level of 1991.

The commercial space launch industry has scheduled six launches of large capacity vehicles in 1992, which are expected to generate revenues of $400 million, compared with seven launches worth $380 million in 1991. Revenues depend on the number of launches and the cost per launch, which ranges from $50 million to $120 million depending on the size of the launch vehicle. In addition to commercial launches, two satellites will be launched for the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce in 1992: the Landsat 6 earth observation satellite on a Titan 2 and a meteorological satellite on an Atlas-E. Six suborbital launches will generate additional revenues of about $8 million in 1992. For further information on the launch industry, see Chapter 21, Aerospace.

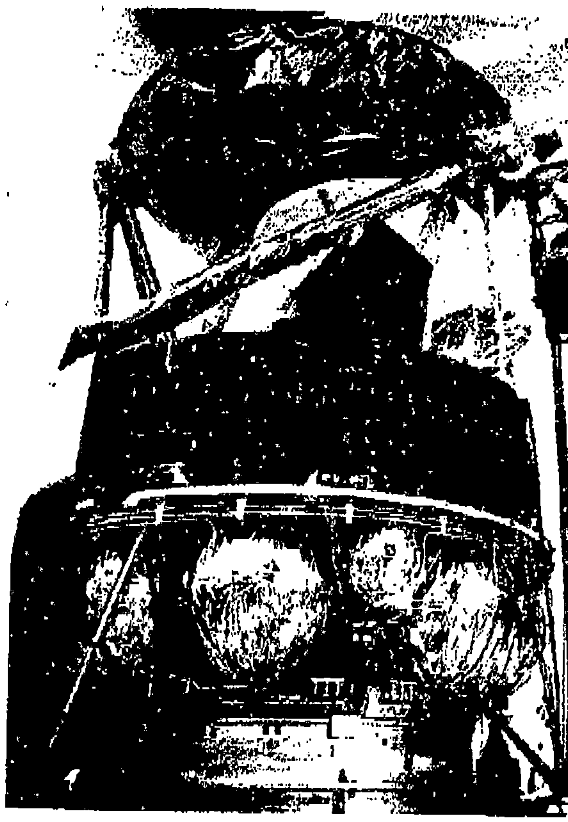
The U.S. satellite manufacturing industry is scheduled to deliver 10 communications satellites worth $1 billion in 1992. This is in contrast to eight communications satellites worth $800 million in 1991. Revenues from the manufacture of ground station equipment and antennas are expected to reach $1.7 billion in 1992, up from $1.3 billion in 1991. The largest markets for fixed earth stations are business communications systems and television receive-only (TVRO) satellite dishes for residential users. The fastest growing market for mobile equipment is for navigation, surveying, and mapping based on the NAVSTAR Global Positioning System (GPS) of the Department of Defense (DOD). More information about these satellite manufacturing industries is provided in Chapter 30, Radio Communication and Detection Equipment.

Long-Term Prospects

The satellite manufacturing industry is expected to continue producing at a high level over the next five years, as most U.S. satellites serving the domestic market reach the end of their operational lives and need to be replaced. Including international sales, the U.S. satellite manufacturing industry has 53 communications satellites scheduled for delivery in the next five years, which represents more than 62 percent of the global market.

The market for small, low-cost satellites, called lightsats and microsats, will continue to develop. Lightsats are satellites weighing less than 1,000 pounds; microsats weigh less than 250 pounds. By 1996, constellations of lightsats in low earth orbits should be capable of providing commercial services for worldwide cellular telephone service, tracking of vehicles and shipments, and digital message services.

The demand for commercial launch services will be relatively flat over the next five years. The launch companies will receive a steady flow of orders to launch U.S. Government civil and military satellites, as well as satellites from foreign countries and international organizations. International competition will increase when the Ariane 5, a new class of larger and lower cost European launch vehicles, enters the market in the mid-1990's.



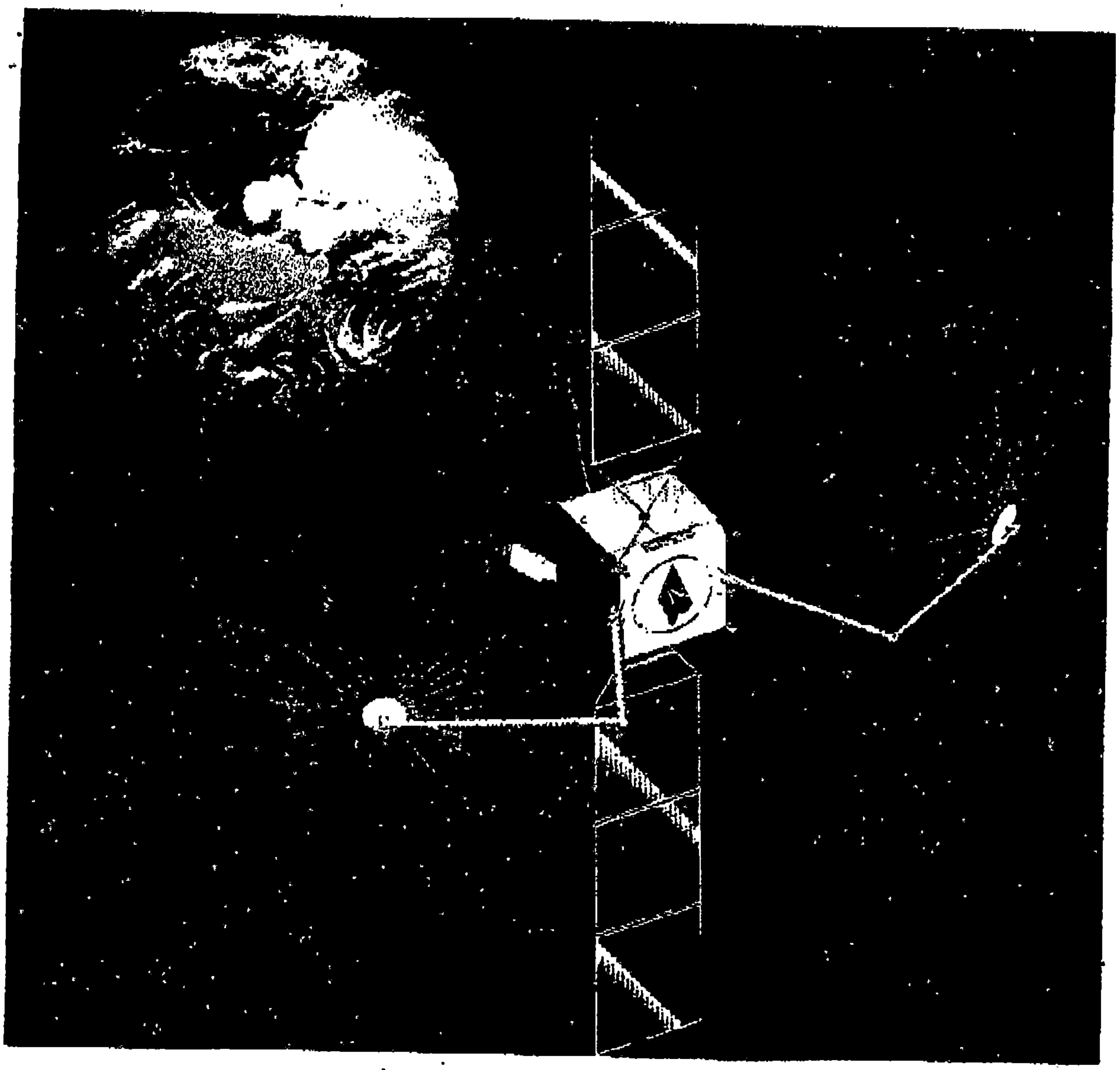
Hughes Aircraft Co.

The U.S. satellite manufacturing industry is scheduled to deliver 10 communications satellites, such as the Intelsat VI-F5 from Hughes Aircraft, valued at a total of $1 billion in 1992.

Long-term U.S. competitiveness in space vehicle technology will improve as a result of the National Space Launch Strategy announced in July 1991. NASA and DOD will cooperate in developing a new generation of launch vehicles, including those with commercial applications, to replace the Shuttle in the next century.

Satellite Services

Satellite services include the major operating companies, which lease transponders (repeaters/amplifiers) on U.S. domestic satellites and transmit to fixed earth stations, and the service providers, which serve mobile users. Total revenues from fixed and mobile services will reach $1.4 billion in 1992, an increase of 13 percent from $1.2 billion in 1991. Nearly 65 percent of revenues from fixed services will be generated by transmitting video for cable TV networks and the national broadcast networks. The largest market for mobile services is the long distance trucking market, which uses satellite equipment for tracking vehicles and transmitting messages between dispatchers and drivers. For further information on satellite services see Chapter 28, Telecommunications Services.



Hughes Aircraft Co.

This HS 601 spacecraft from Hughes Aircraft Co., developed for American Mobile Satellite Corp. to serve the rapidly growing mobile services market, will enable drivers to communicate by car phone, even in remote areas.

Demand for fixed satellite services by business is responsible for most of the recent growth in space commerce. More than 230 U.S. corporations have established private satellite networks for communications of video, voice, and data between headquarters and remote company locations at more than 50,000 sites. Satellite systems are considered more cost effective and flexible than private terrestrial networks linking headquarters with scattered sites over long distances.

Mobile satellite services are the newest market, and growth will depend on the allocation of adequate portions of the radio frequency spectrum to accommodate multiple systems. Market growth will depend on proposed newer technologies based on constellations of small satellites in low orbits, which are challenging the traditional methods based on very large, expensive satellites in geostationary orbit.

Remote Sensing

The remote sensing industry, which experienced a surge in demand in 1991 for satellite images during the Persian Gulf conflict and environmental monitoring afterward, will likely continue to grow at an annual rate of 18 percent in 1992, with revenues reaching $200 million. This includes revenues from sales of unenhanced satellite data, and from consulting firms and service providers. The Landsat 6 satellite, due to be launched in mid-1992, will have twice the resolution of terrestrial features: 15 meters, compared with 30 meters for Landsats

4 and 5. This availability of higher resolution images is expected to generate a surge in demand for the new Landsat data.

In remote sensing, cameras, radar, or other sensing devices in an orbiting spacecraft acquire information about the earth's surface. The Landsat remote sensing satellites are built and owned by the U.S. Government and managed by NOAA. A private company, EOSAT, has operated the Landsat system and marketed the unenhanced data since 1985 under Government contracts.

Worldwide revenues from the sale of Landsat data, including U.S. domestic sales, international data sales, and earth station access fees paid by foreign operators in 16 countries, were about $30 million in 1990. International sales were the fastest-growing market for Landsat data with Asia being the largest foreign market. By comparison, worldwide revenues for SPOT Image, the French remote sensing system, were $32 million in 1990.

Remote sensing satellite applications include agricultural assessments and crop forecasts, land-use planning, oil and mineral prospecting, cartography, forestry, and environmental pollution surveys. More than 200 companies currently offer remote sensing software, systems hardware, and consulting services. The U.S. commercial market has been expanding more than 20 percent a year for the past three years because of the declining cost of computers and data processing, and because mapping technology is shifting from aerial photography to remote sensing data. Satellite data cost less and are more up-to-date than aerial maps for many applications.

The first privately funded and operated remote sensing satellite system was initiated in 1991 with a NASA contract to provide daily ocean imagery. The commercial environmental monitoring satellite, SeaStar, is scheduled to be launched in 1993 and will provide ocean color data to NASA for five years.

Another remote sensing market that has been privatized is the enhancement of images from weather satellites. Satellite images of cloud cover are enhanced by for-profit companies and used by television weather forecasters to show the movement of clouds on TV news programs.

Materials Processing in Space

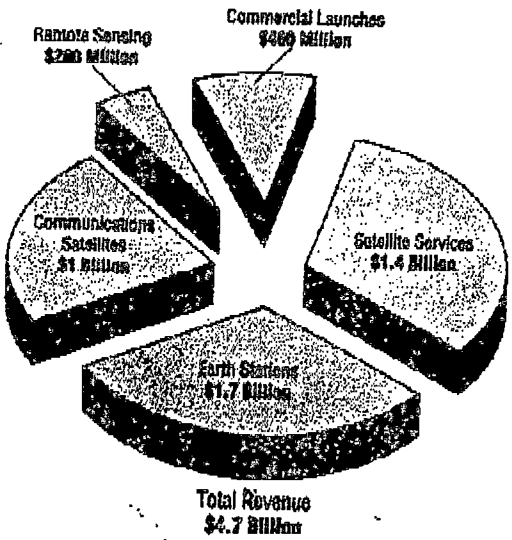
Materials research and processing in space is still a small industry. Few products are being marketed commercially, but Government policy supports research in this area. Several small firms now provide the necessary hardware and services. Commercially oriented experiments have been performed in space to produce unusually strong and light metals, large protein crystals, and pure pharmaceuticals. Experiments that require human-tending for periods of up to 11 days can be performed for private industry on the Shuttle. Short periods of microgravity, necessary for many such experiments, are available from suborbital sounding rockets, drop towers, and parabolic aircraft flights. Microgravity experiments are the major payload for firms offering commercial suborbital rocket launches.

More than 200 U.S. corporations interested in materials research and processing in space and other commercial applications are affiliated with the 16 NASA Centers for the Commercial Development of Space (CCDS), most of them located at universities. The CCDS concept enables firms to learn about the prospects of space materials processing at relatively low cost, and provides access to academic resources.

Research in materials processing will accelerate in 1992, and NASA has increased its funding for commercial launches to carry more experiments into space. In 1991, NASA established a new program for longer duration experiments in space, using a free flying spacecraft and a re-entry capsule to return experiments to earth after orbiting for more than a month. The first launch of the Commercial Experimenter Transporter (COMET) program is scheduled for September 1992.

Figure 41-1

U.S. Space Commerce, 1992



SOURCE: U.S. Department of Commerce: International Trade Administration and Economics and Statistics Administration.

Other nations have developed R&D programs for materials processing in space. The Soviet Union has conducted the most experiments in space because the Mir space station is in continuous operation and can perform long duration experiments. Spacelab, an R&D facility carried by the Shuttle, has been used for special missions by Japan and Germany. In addition, ESA is developing its own R&D spacecraft, Eureka.

Space-based R&D Facilities

A market is developing for privately funded space infrastructure projects designed for space materials research. These projects depend on access to the Shuttle. Spacehab Inc., a commercial company, has raised about $100 million for construction of its Spacehab pressurized metal module for research experiments on the Shuttle, and has a contract with NASA for two flights a year at $30 million a flight. The research module has been leased to private industry, NASA, State Government agencies, and foreign governments.

Commercially Developed Launch Facilities

Privately funded launch sites, or spaceports, are a recent concept. Spaceports are planned for large capacity boosters and for small suborbital sounding rockets. The Florida legislature established the Florida Spaceport Authority in 1990 with a bonding authorization of $500 million. Hawaii also seeks a commercial spaceport. In addition to new spaceports, Alaska's launch facility, Poker Flat Research Range, which is owned and operated by the University of Alaska, is being marketed to private users, NASA, and DOD. State governments are interested in spaceports partly because of spinoffs to research parks, office buildings, and tourism.

Space Insurance

Insurance is essential to the development of space commerce. Space insurance coverage includes loss of vehicle and payload, damage to Government launch facilities, and third-party liability. Vehicle and payload insurance covers the value of the launch vehicle and spacecraft from launch through initial operations, and may include annual coverage for commercial operations. Third-party liability insurance is designed to cover injury or damage to parties other than those associated with the payload and vehicle during launch activities. Requirements for third-party liability and Government property damage insurance are determined by the Secretary of Transportation.

Rates for communications satellites, which average about $100 million in insured value, fluctuate with the number of launch failures and failures of satellites in orbit. Several failures of both launch vehicles and satellites in 1991, which prevented Japanese and Canadian communications satellites from providing service, are expected to raise insurance rates in 1992 to a level of about 20 percent of the value of the launch vehicle or spacecraft. Industry sources report that the amount of insurance, or "capacity," available for a typical launch and payload is about $250 million, which indicates the amount of capital that owners of satellites could lose in a single unsuccessful launch.—*Donald Dalton, Office of Business Analysis, (202) 377–1190, August 1991.*

Additional References

Encouraging Private Investment in Space Activities. Congressional Budget Office, 2nd and D Streets, S.W., Washington, D.C. 20515. Telephone: (202) 224–3121.

NASA Commercial Programs: A Progress Report. Office of Commercial Programs, NASA Headquarters, Washington, DC 20546. Telephone: (703) 557–5609.

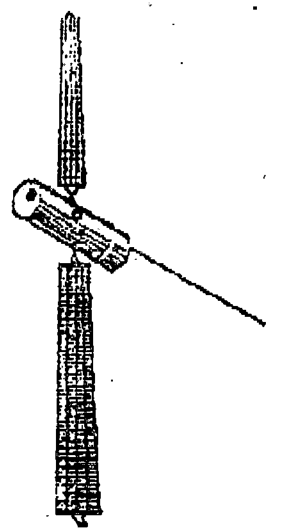
Space Business Indicators. Office of Space Commerce, U.S. Dept. of Commerce, 14th and Pennsylvania Ave., N.W., Washington, DC 20230. Telephone: (202) 377–8125.

Aviation Week & Space Technology, McGraw-Hill, Inc., 1221 Avenue of the Americas, New York, NY 10020. Telephone: (212) 512–2000.

Satellite Communications, Cardiff Publishing Co., 6300 S. Syracuse Way, Englewood, CO 80111. Telephone: (303) 220–0600.

Space News, The Times Journal Co., 6883 Commercial Drive, Springfield, VA 22159. Telephone: (703) 658–8400.

Via Satellite, Phillips Publishing Inc., 7811 Montrose Road, Potomac MD 20854. Telephone: (301) 340–2100.



OFFICE OF SPACE COMMERCE

U.S. DEPARTMENT OF COMMERCE
14th and Pennsylvania Ave., N.W., Room 7060
Washington, D.C. 20230

(202) 377-8125 -- voice
(202) 377-5173 -- fax

To: Gary Gershowitz Date: ______

______ Time: ______

Phone: 456- Fax: 456-6218

From: Scott Pace / Jim Frelk

Pages to Follow: 10

Notes/Instructions:

BACKUP \ SUPPORTING MATERIAL ON COMMERCIAL USE OF NAVIGATIONAL SATELLITES

GPS Proves Its Worth in Operation Desert Storm

by Barry Miller

The US military Services are making major strides in expanding the use of the Navstar Global positioning System (GPS), spurred in part by the successful performance of the highly accurate satellite-based navigation system in the Persian Gulf War.

The Joint Program Office at Air Force's Space Systems Division in Los Angeles has contracts with industry that could add more than 10,000 sets of user equipment to Service inventories by mid-decade, if all options are exercised. Ultimately, purchases could climb to as many as 100,000 user sets, depending on the cost, versatility, and size of new portable, hand-held units for ground forces. The Joint Program Office (JPO) at Air Force Space Systems division, representing all US Services, NATO countries, and other allies, manages GPS development.

In its present configuration of 15 12-hour-orbit satellites, the system provides any properly equipped user with precise position, velocity, and time throughout most of the day and anywhere in the world. Once the full configuration of 21 satellites plus three orbital spares is in place, users will be able to obtain full accuracy at any time. A user with a military receiver can achieve position accuracies of at least 16 meters; those with small, hand-held commercial receivers being purchased in increasing numbers by the military as well as civil users can get 25-meter accuracy. GPS will allow precise control and synchronization of battlefield elements.

Any lingering doubts about GPS's profound military utility were swept away during Operation Desert Storm. Air Force B-52 bombers were aided in locating assigned land targets by GPS airborne receiver sets. The Navy's standoff land attack missile (SLAM), an air-launched derivative of the Harpoon antiship missile used for the first time during Desert Storm, relied on GPS. It obtained position data from an onboard GPS receiver to update its midcourse inertial navigation system in flight before the missile's infrared imaging seeker guided the weapon to its target. The Air Force deployed its two Joint Surveillance and Target Attack Radar System (JSTARS) developmental aircraft during Desert Storm. GPS velocity information, accurate to greater than 0.1 meter per second, was used to help stabilize the militarized 707 aircraft's radar to spot hostile ground vehicle convoys. In one instance early in the war, a search-and-rescue helicopter used GPS to locate and recover an airman downed in Iraq. A senior Army source told *AFJI* that the Army's XVIII Airborne Corps and VII Corps relied on GPS to keep track of their locations during their encirclement of Iraq's Republican Guard.

Trimble Navigation's Trimpack or SLGR

The JPO has bought or has options to buy in excess of 12,000 full military specification user sets for a variety of ships, fixed and rotary wing aircraft, and ground troops, according to USAF Col. Bryan Steadman, user equipment program manager. By September, Rockwell Collins in Cedar Rapid, IA, is expected to complete delivery of more than 4,300 standard receivers under an initial $450-million production contract awarded almost six years ago. The Collins production run, Col. Steadman said, includes approximately 1,800 five-channel receivers for aircraft, more than 400 three-channel sets for ships, 500 two-channel receivers for helicopters, and about 1,700 one-channel manpacks. Recently, the JPO picked SCI Systems, Huntsville, AL, to supply up to 6,000 more of these standard initial production receivers for ships and aircraft over the next five years under a $175-million contract. Additional user equipment related contracts were awarded to E-Systems, St. Petersburg, FL, for antennas and antenna electronics and to Hollingsead International, Santa Fe Springs, CA, for equipment mounts.

In January, Collins received a $10-million contract from the JPO for a miniaturized airborne GPS receiver (MAGR), intended for space-constrained aircraft, primarily the Navy F/A-18 and Air Force F-16B, but also including the Marine AV-8B, Air Force FB-111 and F-15E, and Army AH-64A. Col. Steadman says in excess of 2,000 MAGRs will be bought; the Collins contract has options for about 2,400. The MAGR measures 3" in width, 7" in height, and 12" in depth, or roughly 3/8 the size of the standard airborne receiver. MAGR specifications call for a weight of about 15 lbs, but Steadman said he expects the unit will weigh about 12 lbs, one third the weight of the Collins ARN-141 (V), the full user set incorporating the airborne receiver.

Potential deliveries by mid-decade of the 12,000-plus standard and miniature receivers on contract or under option still fall short of satisfying military needs for about 20,000 US aircraft, nearly 600 ships, and an undetermined number of ground troops and vehicles. Roughly 400 naval ships are now equipped with GPS user equipment, but the percentage of airborne platforms outfitted is smaller. In addition, DoD permits at least some of its organizations to buy GPS receivers directly. Sets for the SLAM missile, for example, and others earmarked for the planned Tomahawk cruise missile Block 3 upgrade are direct buys from Rockwell by individual program offices. Their numbers are not reflected in the JPO figures cited by Col. Steadman.

Remaining aircraft and ship needs will be satisfied in one of two ways starting in the second half of the decade, Steadman explained. The first would be with additional buys of standard and MAGR receivers. Some in industry believe the emphasis will be on the MAGR, rather than on the older receivers, because of its smaller size and interchangeability with the standard receiver. The other possibility, depending on the maturation of the technology, would be the purchase of "embedded," or modular, GPS receivers—chip sets or printed circuit boards with receiver and processor functions mounted on them—for integration with other electronics equipment. A GPS chip set, for example, could be installed within the computer of an aircraft's inertial navigation system.

The drawback to the "embedded" approach, Steadman cautioned, is that it creates and extra logistics requirement conflicting with the desire for a common logistics plan for user equipment.

Concurrent with its efforts to foster

development of airborne and ship-based GPS user equipment, the JPO has been exploring various hand-held user sets for ground troops and others. Evolving technology now permits GPS functions to be packaged into compact, lightweight, rugged units. The Collins manpack now being acquired under the initial production contract weighs 17 lbs. In 1987 the JPO bought 259 10-lb GPS backpacks from Texas Instruments for evaluation by various operators.

Slugger and Plugger

By 1989, the JPO bought an initial quantity of 1,012 Small Lightweight GPS Receivers (SLGR), pronounced "slugger," from Trimble Navigation, manufacturer of commercial GPS receivers in Sunnyvale, CA. This binocular-size, hand-held set meets various military temperature, shock, vibration, and moisture requirements. It weighs approximately four lbs, depending on battery choice.

Unlike military-developed GPS user equipment, the SLGR and other competitive hand-held commercial sets lack both the accuracy and the antijam/antispoof capability of full military sets. It can decode only C/A (clear/acquisition) code signals from each satellite, not the protected P-code which gives military sets both better accuracy and antijam capabilities. In practice, that means 25-meter position accuracy, contrasted to the 16 meter figure for normal P-code-capable user sets.

Nonetheless, a combination of the Gulf War's urgency and increasingly favorable operator response to small, hand-held inexpensive units has sparked a boom for SLGR and other hand-held sets. The JPO has successively exercised a number of options under its Trimble contract to bring the total SGLR buy to 9,200 sets. It also has bought 400 two-lb walkie-talkie-like hand-held sets from Magellan Systems Corporation in Monrovia, CA. The JPO regards these as "interim" devices. Both Trimble and Magellan have orders from other military organizations in the US and abroad totaling several thousands of units. Magellan has sold 500 to the First Infantry Division, an unspecified number of the Marines, 600 to the Saudis, another 600 to the British Ministry of Defence, and 150 to the French. Trimble has had orders for more than 1,500 units from friendly foreign nations including Britain, Egypt, Israel, and Japan.

Individual credit card sales requests for hand-held GPS sets were pouring into both companies from military personnel in the Gulf in recent weeks. During *AFJI*'s visit to Magellan, a junior officer phoned the company from Dhahran for a receiver and made arrangements for payment by his father in the States. Trimble says it declines to accept such individual orders because it is approaching near capacity of 3,000 sets per month. The small hand-held sets typically have calculator-type keypads and small displays permitting users to obtain position readouts in latitude/longitude (for aviation), in Military Grid Reference System (for ground troops), and Universal Transverse Mercator (UTM) coordinates (for artillery).

To satisfy swelling military demand for smaller user sets, JPO is planning to buy a hand-held set called Precision Lightweight GPS Receiver (PLGR), or "plugger." While conceptually similar to SLGR in size, weight, and nature, it will have one important difference. It will be able to decode the P-code for improved precision and antispoof provisions. Col. Steadman said he expects the hand-held or adapter-mounted PLGR to weigh four lbs or less and occupy about 120 cu in, roughly equivalent to the weight and size of SLGR. A PLGR contract is anticipated in 1992 with first deliveries to start in 1993.

The JPO will buy at least 10,000 PLGRs and perhaps many times that number depending on the set's size, usability, cost, and versatility. (Industry estimates project a total potential US market for hand-held GPS receiver sets of 100,000 by 1995, plus a foreign market of about equal size.) The JPO is expecting PLGR logistics to be confined to battery replacement followed by throwaway at expiration of a five-year warranty period. Col. Steadman said he "thinks" the PLGR unit price will be "less than $10,000," compared to about $3,500 for SLGR or its Magellan competitor.

As the PLGR specifications evolve, some in industry insist the additional accuracy of the P-code isn't worth the cost and power penalty for a hand-held unit. They suggest instead a unit capable of decrypting deliberates moves by DoD in wartime to degrade the GPS accuracy available to nonmilitary or unfriendly users. In this selective availability features of GPS, DoD can reduce available position accuracy on the C/A code from 25 meters to 100 meters and velocity accuracy by an unspecified amount by adjusting the satellites' time clocks. If a security module were built into the hand-held set, it could overcome the dilution in the C/A code, assuring a user of the 25-meter accuracy. This might encourage DoD to more readily degrade the potential GPS "civil" accuracy during conflicts in an effort to deprive enemies access to normally available GPS accuracies.

During the Gulf War, DoD elected to leave the selective availability accuracy at 25 meters, presumably because of the proliferation of the small "commercial" user sets among allied ground forces. Since various types of GPS receivers are

Rockwell Collins' GPS manpack

sold commercially here and abroad, the same 25-meter accuracy was available to Iraqi forces. There were reports that the Iraqis used GPS in aligning the guidance systems of mobile Scud missiles.

Airborne GPS user sets installed in high-performance military aircraft generally are configured for either one of two types of operation. They can operate in a stand-alone fashion, isolated from other electronics, giving the crew readings in latitude, longitude, and altitude. Alternatively, they are integrated with other navigation or weapon systems to improve navigation accuracies and weapon deliveries. Typically, GPS user equipment on a B-52 or F-16 routes position and velocity updates to a navigation computer, where it is weighted and integrated with inertial navigation data.

The resulting data then update the aircraft's inertial navigators, which ordinarily drift with time. Tests of such an integrated system on a B-52 yielded position accuracies of nine meters, according to a JPO summary.

The Defense Advanced Research Projects Agency traditionally has taken the lead in furthering applications of GPS. It is sponsoring a Collins development, through Air Force's Space Technology Center, of small, lightweight GPS receivers suitable for military "lightsats"—smaller, special-purpose satellites. It previously sponsored development of generic chips for various types of GPS receivers. Under this program, Collins developed gallium-arsenide, monolithic microwave integrated circuits which demonstrated the potential for simplifying and improving circuitry required for building small GPS receivers. ■☆■

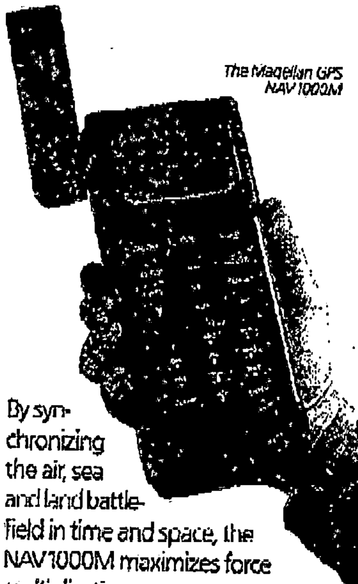
Battle-tested GPS from Magellan. Now faster, more accurate than ever.

Precision navigation at your command.

Used by the multinational Allied Forces during Operation Desert Storm, the Magellan NAV1000M has proven its combat worthiness on the battlefields of the Persian Gulf.

Tested to Military Standard 810D, the NAV1000M now offers greater navigation and positioning capabilities than ever. One-second updates provide continuous position, navigation and velocity data; position averaging capability ensures optimal accuracies (15 meters RMS); a multi-leg patrol function enables enhanced planning and coordination.

A unit-to-unit datalink* provides the instant downloading of critical mission information from one receiver to another, ensuring a well-coordinated operation.



The Magellan GPS NAV1000M

By synchronizing the air, sea and land battlefield in time and space, the NAV1000M maximizes force multiplication.

When weight makes all the difference.

Magellan is the only manufacturer of GPS receivers to successfully integrate gallium arsenide and MMIC technology making the NAV1000M the lightest (0.85 kg) GPS receiver available — about one-half the weight of the competition and easily operated in just one hand.

Rugged, shockproof, waterproof (it floats), and capable of operating for hours on six AA-alkaline batteries, the portable NAV1000M goes everywhere, tracking continuously at speeds up to 870 knots.

A remote antenna and power adapter with quick-release mount* accommodates its use in vehicles such as tanks, HMMWVs, and helicopters making it the most versatile receiver available.

Because accurate decision making is everything:

With information designed for military use, the Magellan NAV 1000M features:

- Position updates every second
- Averaged position accuracy: 15 meters (RMS)
- Single position accuracy: 25 meters (RMS)
- Coordinates in MGRS, Lat/Lon, UTM
- Headings in mils, radians, degrees
- 46 map datums + one user defined
- Stores 100 waypoints
- Calculates targets
- Data transfer: RS232 output
- Satellite schedule calculation

The Magellan NAV1000M. Precision GPS power at your command.

Made in the U.S.A. Warranted for a full year.

For more information, please contact Magellan Systems Corporation, 960 E. Huntington Drive, Monrovia, CA 91016 Phone: (818) 358-[illegible] Fax: (818) 359-4165. Magellan™ and NAV1000M™ are trademarks of Magellan Systems Corporation. *Sold separately.

MAGELLAN
WE BRING GPS DOWN TO EARTH™

6 Dec 90

Dear Trimble,

Thanks a million! I'm a green beret with the Army's 5th Special Forces Group churning up sand here in Saudi Arabia. During my 13 years in SF, I have received one heavy, obsolete peice of equipment after another. During the early 1980's, someone realized that navigation in the various desert regions we are targeted to deploy in might require more than a map and compass so, a crash course in celestial nav was arranged and cheap plastic sextants purchased. By the late 80's, there was still barely a handful of us who could shot a fix and not a current copy of the tables anywhere in the Group.

Now here we are in the empty quarter of Saudi sahara and what do I receive to navigate in addition to my map and compass? You guessed it, a trimble, trimpack GPS! Unfortunately, noone thought to buy the vehicle mounts and external antennais (except the French) but, this thing is fantastic! Flip through the Operations Guide with the GPS in front of you and you're in buisness. I still dead reckon but, with the GPS to shot fixes I'm always on target.

I may return home without having fired my weapon but, your GPS earns it's way every single day and if or when we cross the 'line in the sand' our Trimpacks will be the only piece of equipment everyone will double check to make sure its with us when we go.

So, to Trimble in general and to whoever landed the army contract in particular.

Thank you, you may well save my life...

Gary

SFC Gary D. McDonald
C-3/. 5th SFG (A)
APO, NY 09734

P.S. when we do return they'll be ready to go for mounts and antennas.

oh, and happy holidays!

Saying goodbye to "Where am I?"

SUNNYVALE, CALIFORNIA

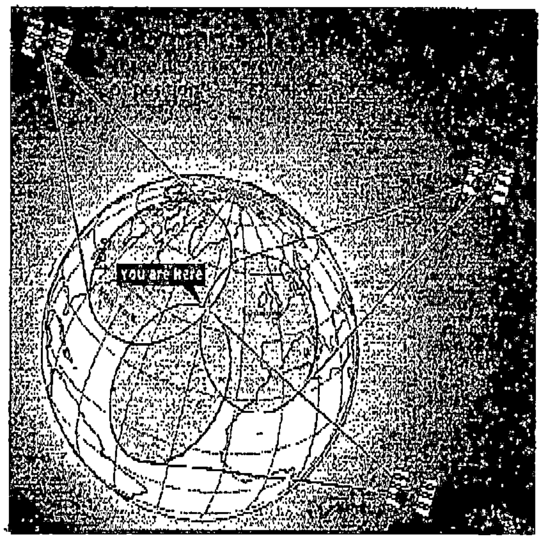
NOT all the satellites in the Gulf war tracked Scuds, spotted hidden bunkers or eavesdropped on whispered orders; some just sat in orbit and warbled coded time signals. But these satellites, which make up the Global Positioning System (GPS), were as vital as any others. They allowed troops with portable radio receivers to find their way across trackless desert and end up exactly where they wanted to be. Having seen its success, the American forces are busily equipping everything, from battleships to cruise missiles, with GPS systems. The technology may have as many applications in peace as in war—or even more.

Sony recently launched a hand-held device which, for a few hundred dollars, will enable the globe-trotting gadget-buff to find out his latitude and longitude—accurate to within 100 metres—whenever he should feel the need. So far, Sony's gizmo remains little more than a hard-to-use gimmick. Though knowing one's latitude and longitude is great for yachtsmen and pilots—the largest non-military market for GPS equipment at the moment—landlubbers prefer to find their way around with landmarks and street-names. Computerised maps make it possible to provide such information. For the moment they are hard to come by, expensive and often clunky to use; given time and incentive, companies will make them cheaper and friendlier.

Meanwhile, companies such as Trimble Navigation, a Silicon Valley start-up which has pioneered civilian use of GPS, and Rockwell, which has built many of the satellites, are busily trying to spot as many markets as they can for GPS technology. They see a vast potential for the ability to know exactly where an object is, at any time.

When finished, the GPS system will consist of 24 satellites built and launched for a cost of about $10-billion. There are 17 in place so far, and the remainder should be in orbit by 1993. After that a regular trickle of replacements will be needed as satellites age and die. By 1995 the Soviet Union expects to have its own constellation, called GLONAS, in orbit. Both systems work on the same principle. Each satellite constantly broadcasts coded signals. A receiver picks up the signals from a number of satellites, and works out how far it is from each of them. Then, using prior knowledge of the satellites' positions, it works out where it is.

To see how it works, imagine you are somewhere in the middle of the Atlantic, armed with a globe, a pair of compasses and the divinely-inspired knowledge that you are 2,000 miles from New York and 2,500 miles from London. To find out where the ship is, use the compasses to draw a circle on the globe with a radius of 2,000 miles and its centre at New York. Draw another with a radius of 2,500 miles and its centre at London. The circles will intersect in two places. The ship is at one of them. Divine knowledge of the distance to a third point—or a passing iceberg—would determine which.



The same principles allow a GPS receiver to calculate its position. The satellites broadcast a fancy time signal, coded in a complicated digital pattern. By comparing the time signal received from space to that generated by its own internal clock, the receiver can—in theory at least—calculate how long it took for the signal to reach earth. Because radio signals travel at the speed of light, the receiver can then calculate the distance to the satellite.

To make use of this information the receiver must also know where the satellites are, just as the mid-Atlantic navigator has to know where New York and London are. Because the satellites are in high orbits, 17,600km (11,000 miles) from the earth, their movements are highly predictable. The receivers are programmed to make such predictions; they can work out where the satellites should be. Then the receiver draws a sphere around each satellite—with the radius of the sphere corresponding to the distance to the satellite—and looks for the point where the three spheres intersect.

Errors can creep in, particularly in the timing system. And as light travels at 300,000km (186,000 miles) a second, a millisecond error can throw off the calculated position by 300km. The satellites have phenomenally accurate atomic clocks, but the receivers do not; their clocks can be a little fast or slow. Charged particles in the air slow the radio waves. Even Einstein comes back to haunt the calculations. The theory of relativity describes the effects that gravity has on space and time: one result is that time passes infinitesimally more quickly in orbit.

Fortunately, these discrepancies can be ironed out. In theory, three signals provide all you need to know to calculate latitude, longitude and altitude. In practice, GPS receivers use four signals; the surplus one allows the receiver to cross-check and catch errors. With only 17 GPS satellites now in orbit, there are times of the day when receivers cannot see four satellites. (Desert Storm troops on the move found themselves taking quick tea breaks during such periods.) But when all the satellites are in place, GPS receivers will work all the time. And if a satellite goes slightly astray, it tells the receivers about its waywardness, so that their calculations stay exact.

Positions calculated from GPS signals should be accurate to within 25 metres. But America's generals can reduce accuracy for non-military users to about 100 metres. Their "selective availability" option introduces an artificial error into the satellite's signal which confuses civilian receivers. Since the war with Iraq, selective availability has been in force. For really accurate work, even degraded signals from space can be used in tandem with signals from a transmitter at a known, fixed position on earth. This so-called "differential GPS" is accurate to within centimetres or less. Geologists use it to monitor fault lines.

With experience, the cost of the chips needed to make GPS receivers has fallen to a few hundred dollars. It is still dropping fast. Enthusiasts predict a boom in GPS applications. Stephen Colwell of Colwell-Kirtland International, a sort of information broker for the GPS market, says that he is getting six or seven inquiries a day about possible new applications. Charlie Trimble predicts that his eponymous firm's sales will increase from about $40m in fiscal-year 1989 to $4 billion by 1995. If so, most of that growth will come in four markets:

- Commercial navigation. GPS systems are already being fitted to aeroplanes and ships. The system is many times more accurate than existing navigation aids, which rely on a network of ground-based radio signals.
- Geographic information systems. Cities are using GPS surveying equipment to map the location of everything from fire hydrants to suburban housing.
- Vehicle tracking. By putting GPS receivers and radio transmitters on everything from ambulances to individual cargo containers, companies can better track the movement of their assets—and so boost efficiency.
- Car navigation. Tied to a database of digital maps held on a CD-player in the boot, GPS systems may one day eliminate the need for paper maps. Several companies, including Pioneer of Japan and Etak, another Silicon Valley start-up, have systems for telling motorists how to get from A to B (see box).

To these markets may be added a fifth: the consumer. Receivers could soon become small and cheap enough to fit into a businessman's briefcase. Compact discs are also getting smaller, so it should soon be possible to create, say, a traveller's guide that not only tells you where the good restaurants are, but also tells you how to get there from wherever you happen to be at the moment.

The whole business depends on the military keeping the system operational and available. But with two systems, one Russian and one American, there is a certain security. One Northwest Airlines jumbo jet is already using signals from both constellations of satellites to navigate. If the technology finds as many uses as its proponents hope, satellite navigation systems might make sense even without the military footing the bill. The day may come when knowing exactly where you are is as commonplace as checking the time on your watch.

Genes and disease

Evolving defences

ACCORDING to Darwin, life adapts to the challenges it encounters. In Africa, one of the great challenges to human life is malaria. So how have people adapted? Until recently, there was one well known answer: the sickle cell mutation, which confers a resistance to malaria, but at the cost of making people anaemic. Now a team based in Oxford has found more adaptations: they are intriguing to those who study evolution, and exciting for those who make vaccines.

Every gene comes in various different forms, called alleles; each allele contains instructions for making a slightly different version of the same protein. Most proteins do not vary much, so most genes have one dominant allele. But there is one set of proteins which comes in more than enough varieties to please Mr Heinz; the HLA proteins on the surface of cells, which play a role in triggering and controlling the immune system, are described by a small set of genes which all have lots of alleles.

Such profligacy demands explanation. Mathematical models show that random processes should make some alleles become more abundant and others die out—just as

4° East, 51° North, and a side order of 29

MENLO PARK, CALIFORNIA

KNOWING where you are is not much use if you don't know where everything else is. That is why any boom in the personal use of GPS equipment will be followed by a boom in sales of digital maps—and will not happen before those maps are available. With this in mind, Rupert Murdoch recently bought a small Silicon Valley mapmaker called Etak. Not only does the publishing magnate think he has a good product; he also thinks that digital maps could be the advertising medium of tomorrow.

Etak was founded in 1983 to develop a car-navigation system created by its founder, Stan Honey. Sales have so far been disappointing, so the company has shifted its focus to digital map-making. Not only is there a steady demand for digital maps from cities and others looking to modernise their records, but Etak also feels it has a competitive advantage in digital map-making technology.

Thanks to Marvin White, whom Etak hired from America's Bureau of the Census, the company was one of the first to apply the principles of topology—the mathematical study of shapes—to computerised maps. Many early attempts at digital map-making simply traced roads, rivers, boundaries and whatever into the computer. Though straightforward, this approach makes it easy for errors to creep in. Because the computer has no concept of what a boundary is, it is quite happy if the co-ordinates for, say, the eastern border of France do not quite meet those of Germany's western boundary—leaving a tiny gap neither here nor there.

Etak incorporates into its map-making program the basic concepts of topology: point (a position), line (something that connects two points) and region (a surface enclosed by lines). This helps the computers detect and correct errors. Roads, for example, are represented as lines running between intersections, which are represented as points. The software therefore assumes (usually rightly) that if two roads cross at a point that is not noted as an intersection the map maker feeding it instructions has erred.

Topological knowledge also makes databases easier to use. Etak's map database can answer several types of question. It can translate place-names and addresses into latitude and longitude (and vice versa) and it can find a route between two places. In this it is helped by a hierarchy that tells it to look at motorways first when looking for a way to cross long distances, and to look at dirt-tracks only for the last bit of the trip to the Love Shack, or any other backwoods destination.

Combined with GPS position-finding equipment, such route-finding abilities could answer questions like, "where is there a good Chinese restaurant near here?" as well as, "where is 2225 Main Street?" Indeed Mr Murdoch reckons that such maps could be the new "Yellow Pages"—and that, as they do in the "Yellow Pages", companies will pay for a listing.

Airborne Imaging, GPS Aid Aircraft, Firefighters in Battling California Blaze

RICHARD G. O'LONE, BRECK W. HENDERSON/SAN FRANCISCO

Sophisticated airborne imaging and mapping systems, as well as an intense application of aerial fire-fighting equipment, were among resources used in combating the Oakland-Berkeley hills fire—the worst in California history.

The firestorm, which began Oct. 20, led to at least 22 deaths, the loss of more than 3,000 homes and damage estimated at $5 billion. In addition to ground-based methods, it was fought by fixed-wing tankers and helicopters, mapped and photographed by aircraft from nearby NASA-Ames Research Center and tracked by hand-held global positioning system (GPS) receivers like those used in the Persian Gulf war. Aerial tankers dropped nearly 60,000 lb. of retardant in two days.

Two NASA aircraft—a C-130 transport and a high-altitude ER-2—provided ground managers with high-resolution infrared (IR) imagery and video that helped determine the severity of burning areas and outlined the limits of the flames. The transport, equipped with two thermal scanners and video cameras, made 12 passes over the area on Oct. 21 at altitudes of 5,000-18,000 ft. The ER-2 produced IR video photos of the entire region from 65,000 ft.

NASA officials said the infrared image was overlaid with position data provided by the aircraft's inertial navigation system, and then recorded on videotape while still airborne. After completing its passes over the fire, the C-130 landed at Oakland International Airport and the 2-hr. tape was turned over to California Highway Patrol personnel, who delivered it by helicopter to the fire command center. The tape identified two locations where flames had jumped the perimeter that ground firefighters were attempting to establish, Ames officials said.

FIRE PLOTTED WITH GPS

Photos from the ER-2 were transmitted to Ames, which passed information on changes in the fireline to the command center. However, IR sensing was inhibited later in the day as low-level clouds developed over the area.

IR wavelengths can penetrate smoke, but not water vapor, Ames scientists said. There were no other clouds nearby, they said, and they speculated that as heat generated by the huge fire rose, it created a vacuum that sucked in moist air from the offshore marine layer, forming clouds only over the heated area.

Volunteers from Trimble Navigation, in Sunnyvale, Calif., used global positioning system receivers to track the spread of the burning area by helicopter on the evening of Oct. 20 and to survey damage the next day.

They used Trimble's Pathfinder, a commercial system similar to the military model used by ground troops in the Persian Gulf war (AW&ST Feb. 11, p. 77). The hand-held units, about the size of a car radio, provide 15-25 meter accuracy, or better.

Charles Branch, Trimble's Pathfinder product manager, said that until company volunteers arrived with their equipment on Oct. 20, firefighters outside the command post had no comprehensive picture of the extent of the blaze. Chuck Gilbert, a Trimble engineer, convinced disaster officials of what his equipment could produce, and he was put on a California Highway Patrol helicopter with a Pathfinder. The antenna was strapped to the outside of the aircraft.

The helicopter flew around the perimeter of the fire in about 1 hr. with the receiver recording its location once every second, and returned to Alameda Naval Air Station. Gilbert downloaded the data into a laptop computer and printed out a plot of the area in about 5 min.

The plot was laid over a map, duplicated and sent to firefighters in the field to help them track the spread of the blaze.

Trimble volunteers returned to the area the next day to assist in damage assessment. An advanced model of the Pathfinder logs text information in addition to location to permit easy identification of homes or utilities. Branch said four workers on the ground and one in the air mapped the entire burn area in detail and logged the location of 1,750 burned homes and other buildings in about 3 hr. The California Dept. of Forestry (CDF) estimated the job would have taken more than 30 hr. without GPS equipment, Branch said.

Branch said he expects utility companies and others to continue using the GPS receivers to locate such items as damaged public utility equipment and assess its condition. Road maps of the extremely steep, rugged Oakland terrain were not adequate, Branch said.

Aerial fire fighting was hampered by the fact that the conflagration, while highly destructive, was concentrated in a relatively small area with hilly terrain. It also was located within Oakland International's terminal control area (TCA), which added to the difficulty of coordinating and maneuvering the fire-fighting aircraft, according to Olis H. Kendrick, senior air operations officer for the forestry department, which conducted the aerial attack. The department used 10 fixed-wing tankers and about 20 helicopters with water buckets carried as sling loads.

Reversal in Strategy Will Separate Cessna From General Dynamics

NEW YORK

General Dynamics Corp.'s decision to divest its Cessna commercial aircraft division, a reversal in strategy from just two months ago, was made after the company "digested the full implications" of $3 billion in new defense business earlier this year, James R. Mellor, president and chief operating officer, said.

Once General Dynamics concluded that it should focus exclusively on its core business—defense—Cessna was viewed as a "management diversion," Mellor said. Another major factor in General Dynamics' decision to sell Cessna was the relatively low value shareholders were receiving, Mellor said.

In interviews with Mellor and Chairman and CEO William Anders in July, Cessna was touted for its current and projected contribution to GD's bottom line (AW&ST Aug. 5, p. 38). This year Cessna, which has about 60% of the civil aircraft market, is expected to generate more than $800 million in sales and up to $100 million in profit.

Within 4-5 years, Cessna could account for more than 30% of total GD operating profits, compared with an estimated 22% in 1991 and 13% in 1989.

For this reason a growing number of security analysts are perplexed by GD's action, particularly when one of the company's objectives is to build liquidity.

"It seems pretty clear the company's senior management has a mandate to liquidate [General Dynamics]," one senior analyst said.

General Dynamics is considering three options for Cessna's disposition: outright sale for cash, an initial public offering or a spinoff to shareholders. Cessna could fetch from $500-700 million. □

onaut Pledge

ny grades in science, mathematics and
nd to help others towards these goals."

the Program?

"When the students beg to be allowed to join the next year, you know the program is good."
Kim Tindel
Deltona, FL

"Young Astronauts provides a way to build a better self-image along with better grades in science and math."
Barbara Moreau
Forked River, N.J.

"As enthusiastic supporters of your goals and initiatives, we are happy to be affiliated with your group as Honorary Co-Chairmen."
George and Barbara Bush
The White House

The Young Astronaut Council
P.O. Box 65432
Washington, D.C. 20036

JOIN
The YOUNG ASTRONAUTS

YOUNG
ASTRONAUTS™
USA

Young Astro

"I pledge my best efforts to improve …
related subjects, to learn about space a…

What are People Saying About …

"Your program is the biggest bargain I have found in 18 years of teaching! It does a fabulous job of teaching that science is all around us and that it's fun and so interesting. It really has turned my kids on."

Sandra Bagley
Greenway, LA

"This splendid private sector initiative has captured the imagination of thousands of students across this great land. Educators, parents, business, industry, and professional groups have enthusiastically embraced this initiative to improve the scientific and mathematical skills of our nation's youth."

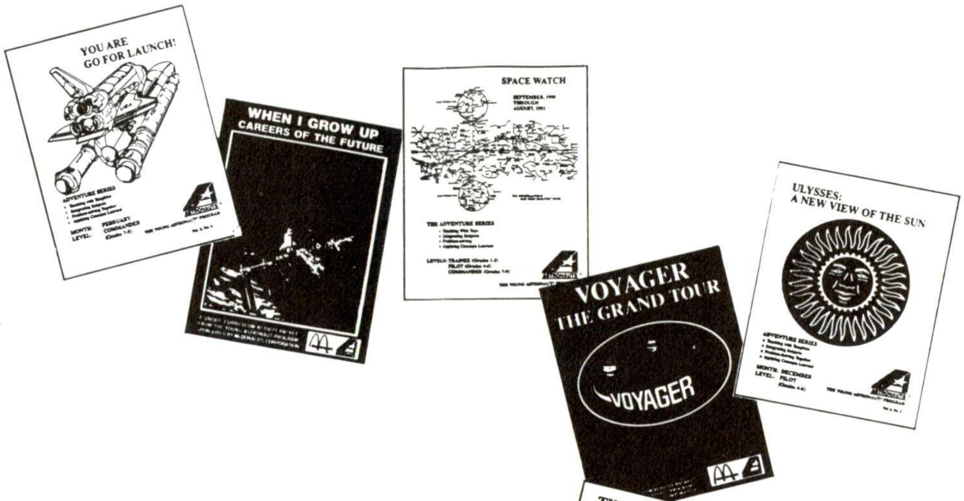
Ronald Reagan

"I've never seen anything ignite kids as much as the Young Astronaut Program."

Julie Taylor
Hesperia, CA

	QTY	AMOUNT	SUBTOTAL
CHAPTER MEMBERSHIP Name ______ School Name (if applicable) ______ Address ______ City ______ State ______ Zip ______ Daytime Phone Number ______ Preschool ______ Trainee (1-3) ______ Pilot (4-6) ______ Commander (7-9) ______		× $40.00	
INDIVIDUAL SATELLITE MEMBERSHIP Name ______ Address ______ City ______ State ______ Zip ______ Daytime Phone Number ______		× $5.00	
T-SHIRTS Name ______ Address ______ City ______ State ______ Zip ______ Daytime Phone Number ______ Size: Small ______ Medium ______ Large ______ X-Large ______		× $7.95	
CAPS Name ______ Address ______ City ______ State ______ Zip ______ Daytime Phone Number ______ Size: Small ______ Medium ______ Large ______ X-Large ______		× $4.95	
YOUNG ASTRONAUT BOOKS The Young Astronauts		× $2.00	
The Young Astronauts #2: Blastoff		× $2.00	
Send Orders To: Young Astronaut Council P.O. Box 65432 Washington, D.C. 20036 (202) 682-1984			
	TOTAL		

START A YOUNG ASTRONAUT CHAPTER IN YOUR SCHOOL OR



WHAT IS THE YOUNG ASTRONAUT PROGRAM?

The Young Astronaut Program is a national educational enrichment program that uses space to open up the world of science, math and technology for elementary and junior high school students. Hands-on activities allow children to discover the fun of learning and increase their abilities. More than 25,000 chapters have been formed in every state and in 42 foreign countries.

WHAT DO YOUNG ASTRONAUTS DO?

Young Astronauts learn about science and space through creative experiments and other activities. They participate in national contests and get to meet others who share their interest in science and space at national and international conferences.

HOW IS THE PROGRAM ORGANIZED?

Young Astronauts are organized into Chapters of up to 30 students led by a volunteer adult, usually a teacher. Chapters receive high-quality, space-related curriculum materials sufficient for 2-3 hours per week. The materials developed by curriculum specialists are produced in four levels: Pre-school, Trainee (grades 1-3), Pilot (grades 4-6) and Commander (grades 7-9).

WHAT DOES IT COST TO JOIN?

There is an annual $40 Chapter membership fee which includes all members. Chapters frequently are sponsored by community organizations such as PTA, Kiwanis, the Civil Air Patrol and the Air Force Association, all of which have endorsed the Young Astronaut Program at the national level.

HOW DO I FORM A CHAPTER?

Simply return the application form from this brochure. You will receive membership cards and certificates, a Chapter Leader's Handbook and sample curriculum materials. Subsequent curriculum packages arrive regularly throughout the school year.

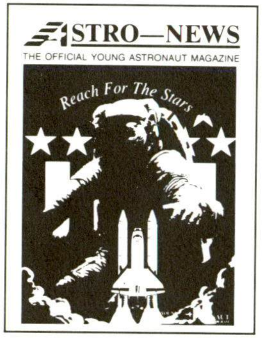
BECOME AN INDIVIDUAL SATELLITE MEMBER

DO YOU HAVE THE RIGHT STUFF?

Join thousands of other students in the pledge to improve your grades in science, math and technology.

Satellite Members Receive:

- Membership Card and Certificate
- Opportunity to Participate in National Contests and National and International Conferences
- Quarterly issues of ASTRO-NEWS*



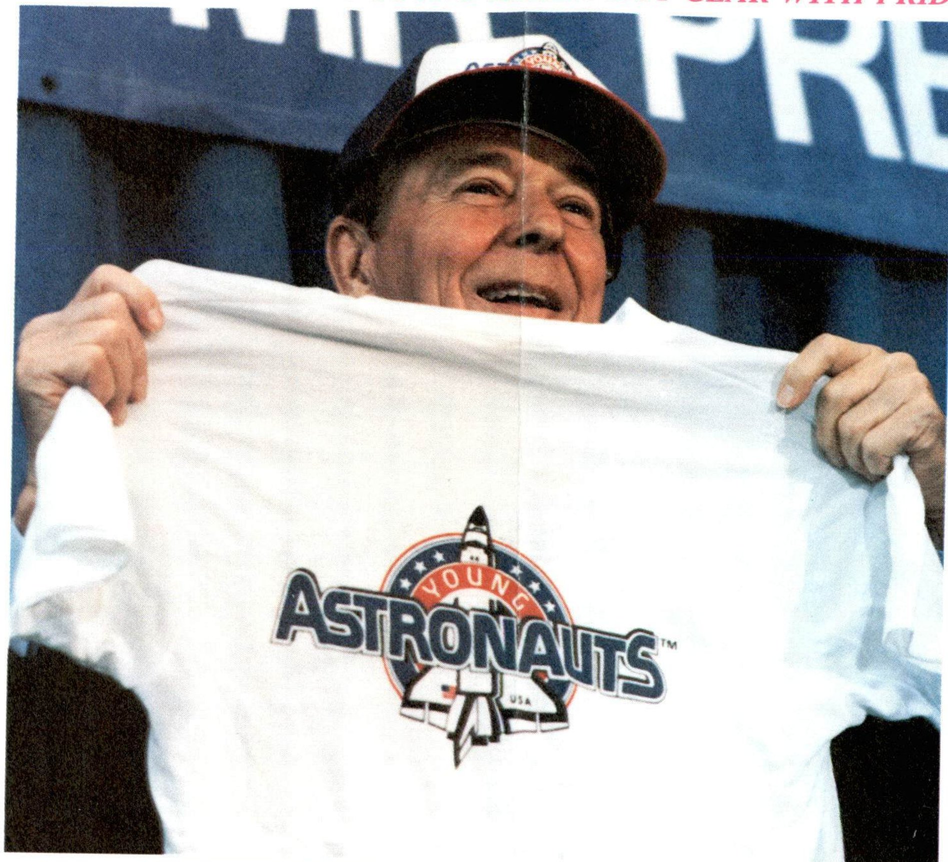
ASTRO-NEWS is filled with interesting facts and information about science and space:

- Answers to frequently-asked questions about space travel
- Everyday uses for space-related developments
- Interviews with astronauts and those working in the space program
- Latest information on NASA activities
- Simple science experiments to do at home
- Games and puzzles

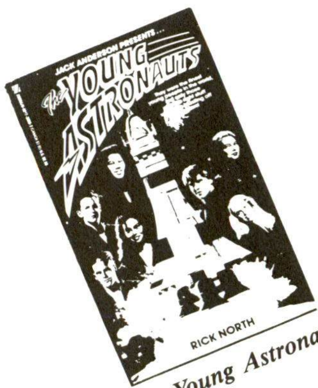
Satellite membership is only $5 a year.

*First issue available in January 1992

WEAR YOUR OFFICIAL YOUNG ASTRONAUT GEAR WITH PRIDE



Follow the adventure of the Young Astronauts Mission to Mars through the Young Astronauts adventure series.

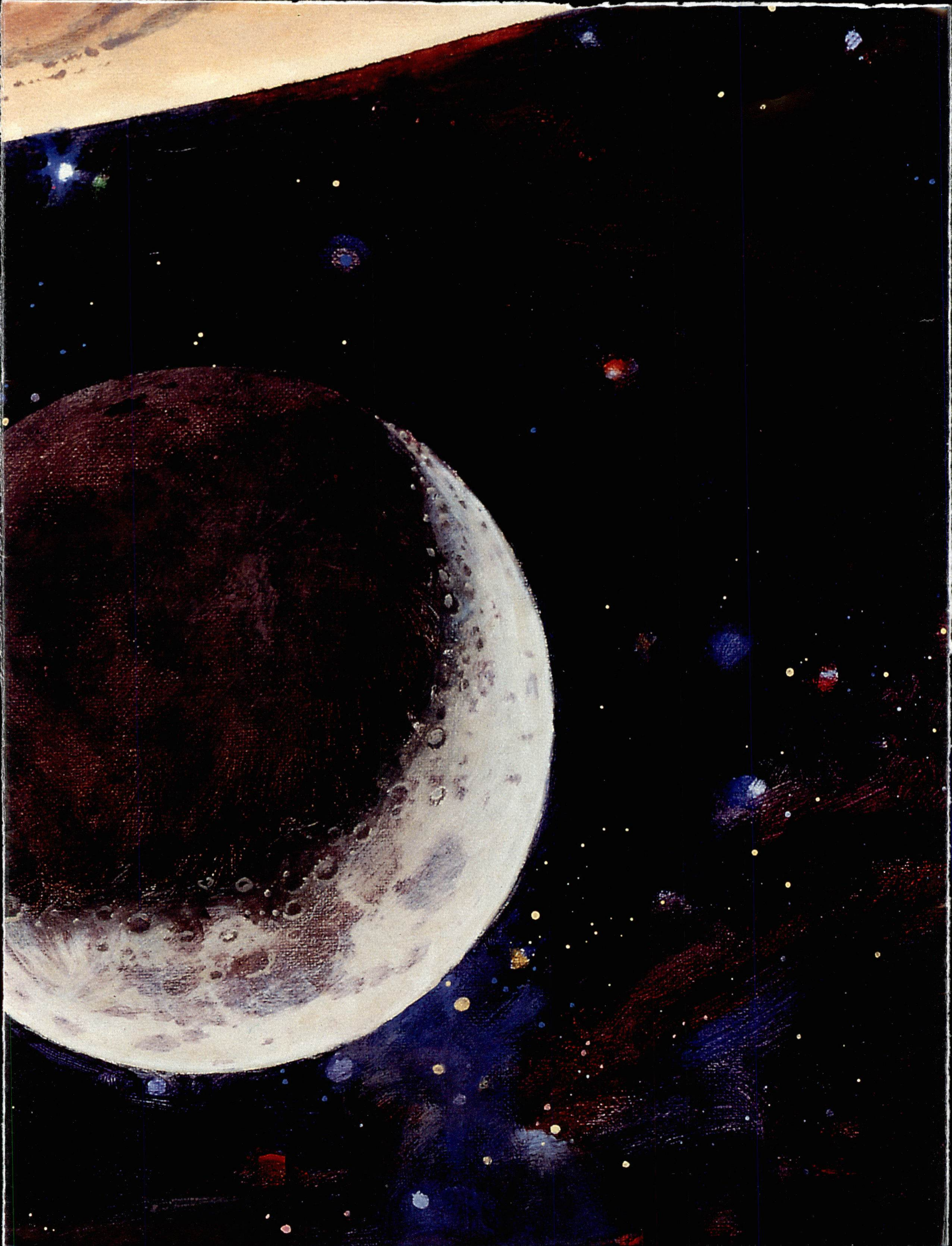


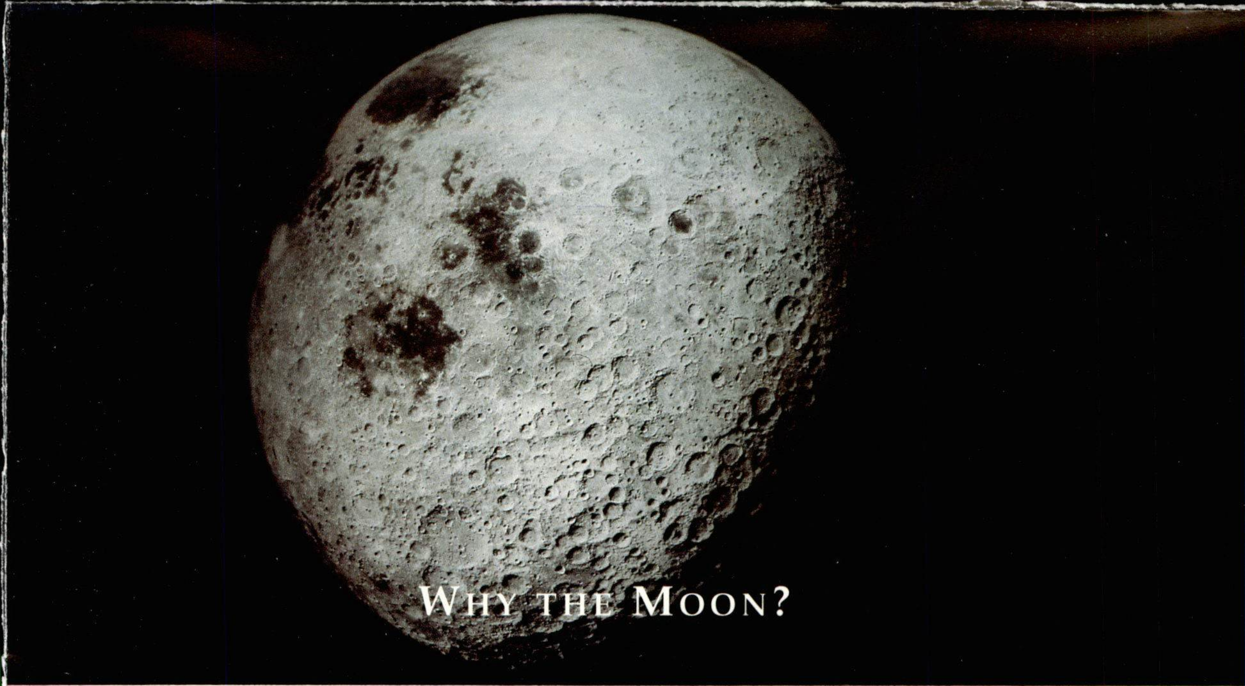
The Young Astronauts

The Young Astronauts #2: Blastoff

AMERICA
AT THE THRESHOLD

AMERICA'S
SPACE EXPLORATION INITIATIVE





Why the Moon?

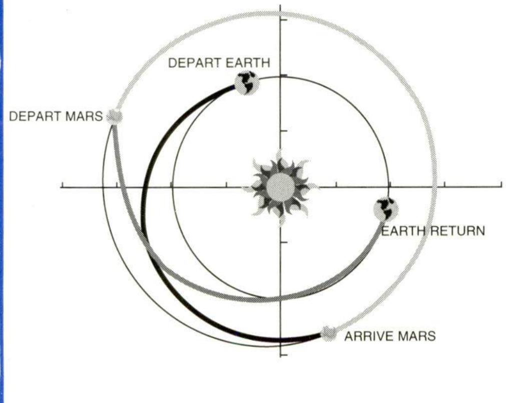
Earth's closest neighbor in space, the Moon, is surprisingly complex. It is an object for detailed exploration, a platform from which to observe and study the universe, a place to live and work in the environment of space, and a natural source of materials and energy for an emerging space-based economy.

The Moon offers a record of four billion years of planetary history. Its violent birth and history of bombardment from space is closely related to events on the early Earth. The Moon provides a natural laboratory for detailed study of geology and planetary formation, the output of our Sun over its lifetime, and the elements of our universe. The Moon's two-week night, crystal clear, airless sky and stable ground provide a superb platform for astronomy.

Just three days journey from Earth, the Moon is the nearest object in space where people can live under conditions similar to those we will face on other planets. Thus, the Moon is a natural test bed to prepare for missions to Mars by conducting simulations, systems testing, operations and studying human capabilities.

The Moon is a rich source of materials and energy for use in space. Abundant metals, ceramics and recoverable amounts of hydrogen, carbon and oxygen can provide propellant and human life support from the lunar surface. The two-week daytime provides abundant solar energy. Our Moon provides a rich scientific and economic waystation for human expansion into the solar system.

TYPICAL CHEMICAL PROPULSION MISSION
TOTAL MISSION: 919 DAYS
2014



MISSION TIMES

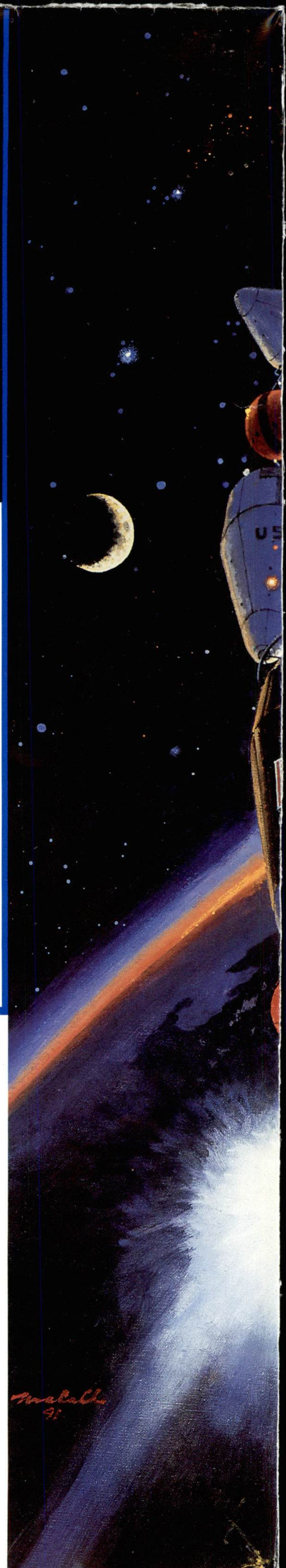
OUTBOUND — 224 days
STAY — 458 days
RETURN — 237 days

The Pathway to Mars

At its closest point, Mars is 35 million miles from Earth. This distance increases to 250 million miles when we are on opposite sides of the Sun. By comparison, the Moon is only a quarter million miles away — a three-day journey. The challenges of a Mars expedition stem from the distances, the long times away from Earth, the environment of deep space, and Mars' unique characteristics.

A total Mars mission duration depends on both the round trip travel time and the time spent on the planet's surface. A typical conventional chemical propulsion mission would take about 250 days one-way with a surface stay of about 500 days to allow the planets to realign before returning home. Advanced nuclear propulsion technologies can shorten the trip to 160 days or less each way. This would allow more time for exploring Mars and provide longer launch windows, all with lower propellant mass.

Shorter travel times are desirable to reduce the impact of the deep space environment on the crew and mission equipment. During the space voyage, expected hazards include radiation from galactic cosmic rays and solar flares, the lack of normal



THE SPACE EXPLORATION INITIATIVE

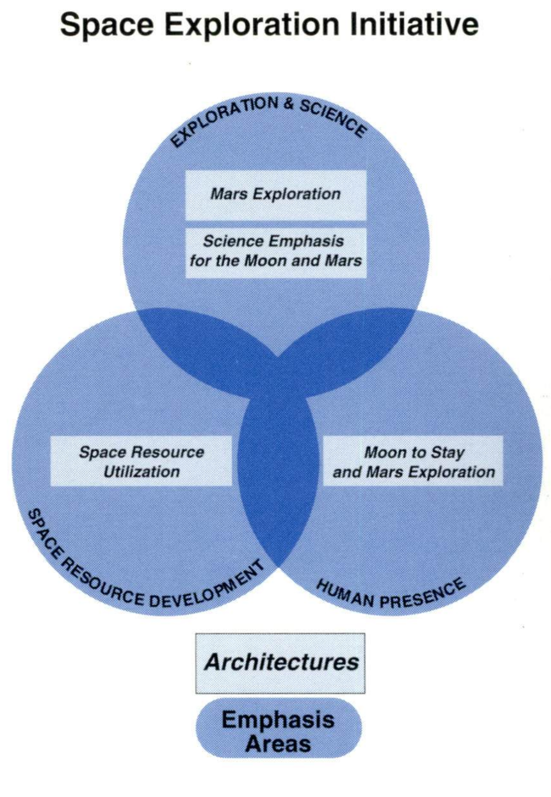
Apollo 11 first placed America on the Moon on July 20, 1969. This extraordinary accomplishment confirmed the United States' technological ascendancy for a generation. On the 20th anniversary of Apollo 11, President George Bush announced a new vision for America in the 21st century — a vision that will return mankind to the Moon to stay, and onward to land humans on Mars by 2019. This vision, the Space Exploration Initiative, represents the greatest challenge the world has ever known.

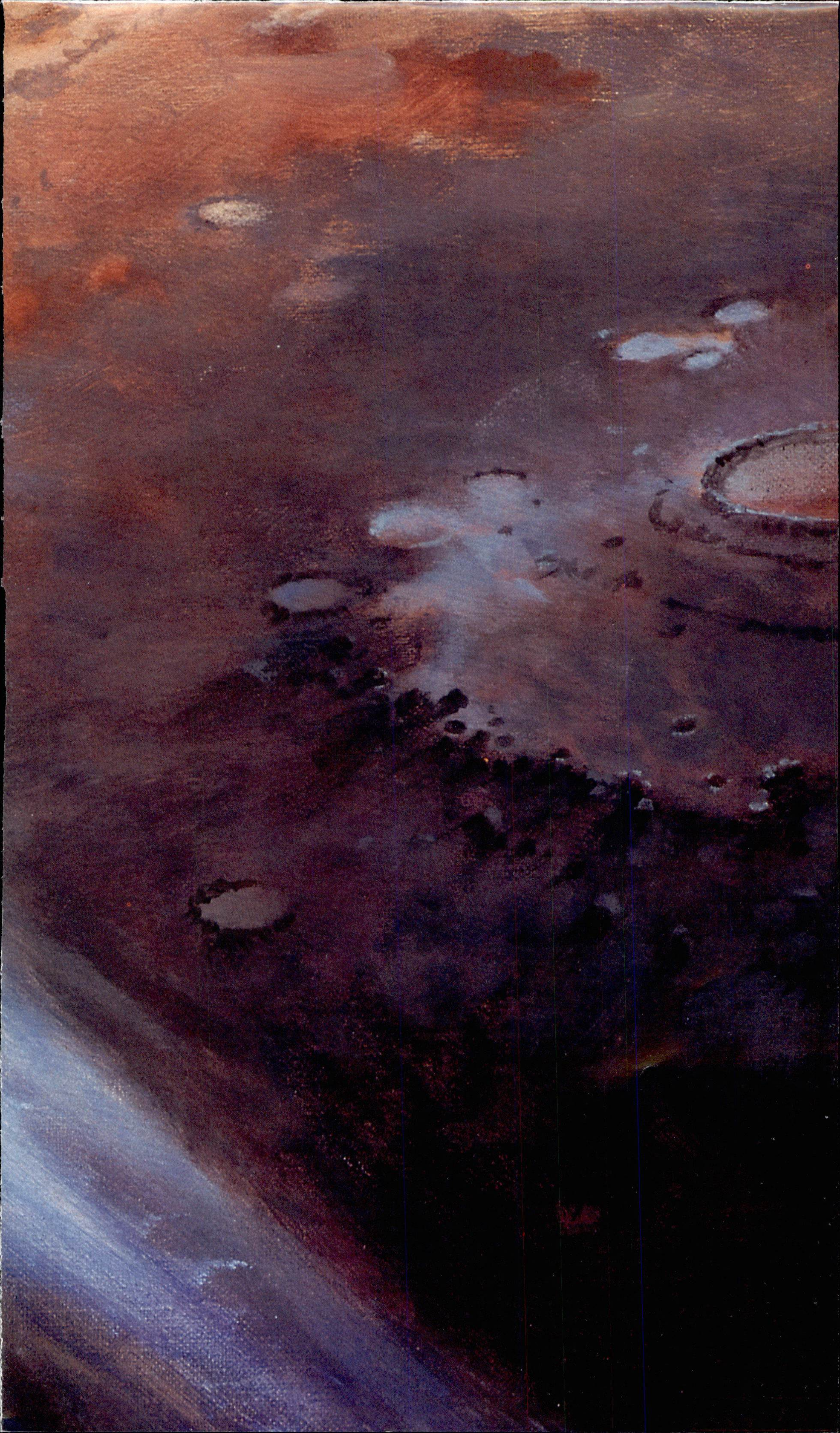
Following preliminary studies by NASA, Vice President Quayle, as Chairman of the National Space Council, directed an extensive Outreach Program. The Outreach Program challenged Americans to search for new and innovative ideas and technologies to make space exploration safer, faster, better and more affordable.

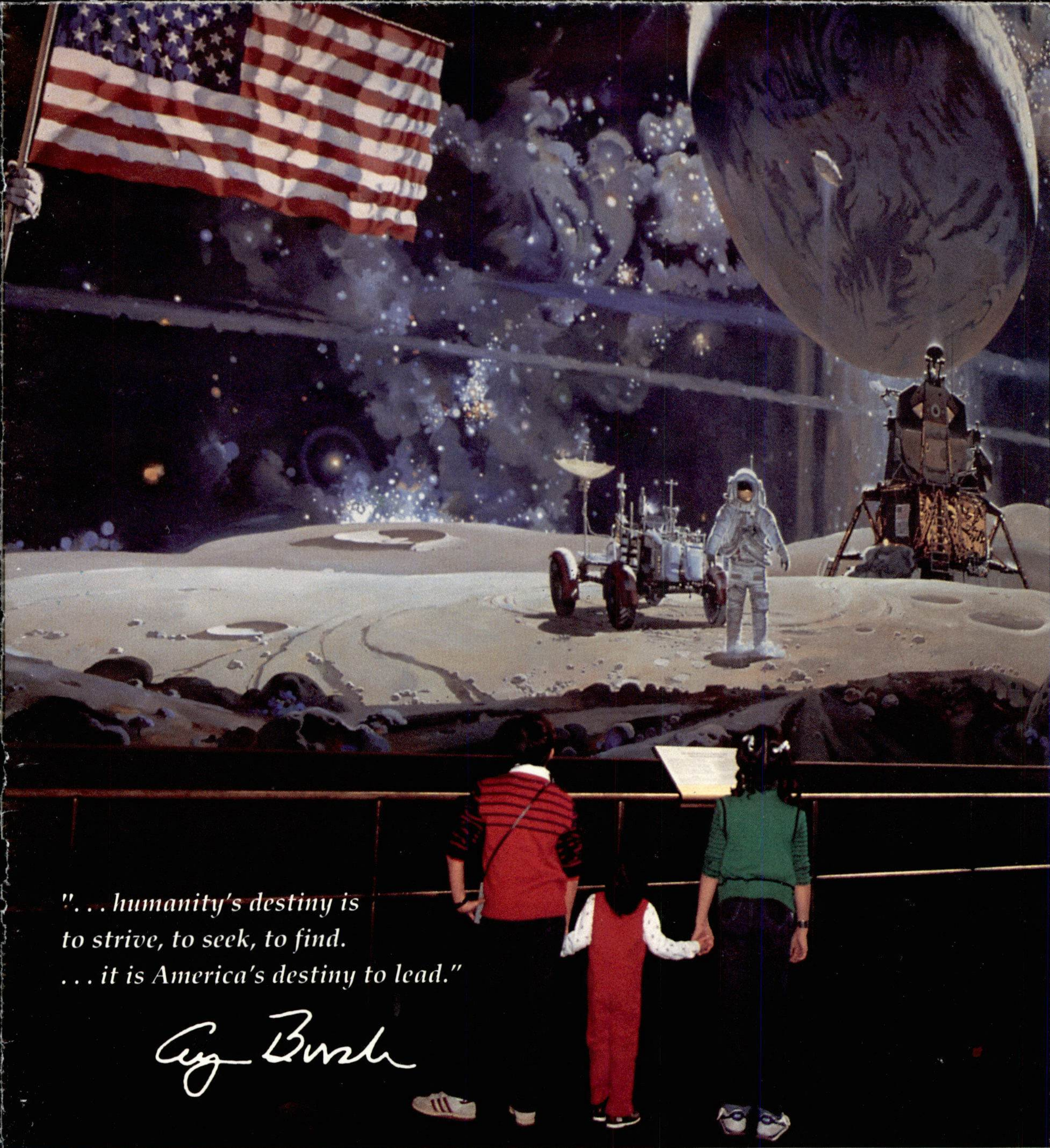
Vice President Quayle tasked former Apollo astronaut Lieutenant General Thomas Stafford, USAF (Ret.), to assemble "the Synthesis Group," an independent panel of recognized experts. Staffed by the best technical talent from across the United States government, industry and academia, the Synthesis Group was chartered to assess the widest possible range of innovation from all available sources, and to define technology priorities, early milestones and alternative architectures for the Space Exploration Initiative.

The four architectures developed by the Synthesis Group provide alternatives. All are real pathways for returning to the Moon and then onward to Mars. *All architectures offer three common areas of emphasis: human presence, exploration and science, and space resource development for the benefit of Earth.* The alternative architectures are covered in detail in the Synthesis Group's report. This brochure highlights the common needs and the challenges we face.

The challenges of the Space Exploration Initiative are great, but so is the quality of American talent and ingenuity, and so is the leadership of the American people. And . . . it is America's destiny to lead.







THE CHALLENGE

In 1989, President George Bush challenged America in a way no one has challenged us before: "Back to the Moon to stay, and onward to Mars." In the history of the human race, no challenge has been so great, and no goal so distant. Likewise, there has never been a nation like ours, nor an opportunity so promising.

Ours is a rapidly changing world. To remain competitive and maintain world leadership in the 21st century, America will need the best trained and educated work force, the most advanced technology and the strongest leadership. And we will need goals that challenge our abilities far beyond what we've experienced before.

The Space Exploration Initiative is a vision for the 21st century. It is a vision of America reaching beyond itself, and onward, beyond the very bounds of this planet to an entirely new world. On the way there, we will reap the real, tangible benefits of space exploration.

Space is clearly our most challenging frontier. Enroute to Mars, we will explore the Moon, advance Earth sciences, and develop new, innovative technologies. We can tap lunar, Martian and solar energy resources as we explore the heights of human talent and ability. Along the way, American drive, initiative, ingenuity and technology — all those things that have made this nation the most successful society on Earth — will propel us toward a future of peace, strength and prosperity.

The challenge is before us. Here is how we begin.

THE SPACE EXPLORATION INITIATIVE
"VISIONS FOR AMERICA"

The Space Exploration Initiative provides a focus that will allow the United States to seize control of our destiny in space. In doing this, six "visions" guide and direct our space efforts. These are:

Knowledge of our Universe. We strive to understand the origin and history of our Solar System, the origin of life, and the ultimate fate of our universe. People are the best explorers, but they often need machines to help. *The Space Exploration Initiative is an integrated program of missions by humans and robots to explore, to understand, and to gain knowledge of the universe and our place in it.*

Advancement in Science and Engineering. Returning to the Moon, and onward to Mars will require the best engineering and scientific talent our nation can muster. Through a long–range commitment to space, we will stimulate our national education system and inspire students to learn. Motivated students are essential to excellence in education. *The Space Exploration Initiative will motivate and inspire the new generations on which our future as a nation depends.*

United States Leadership. The Space Exploration Initiative provides us with an opportunity to re–establish and maintain American pre–eminence in technological innovation and space leadership. Other nations have seized the initiative and become leaders in a tradition of space exploration that America pioneered. *Leadership cannot be declared ... it must be earned.*

Technologies for Earth. America's recent history has demonstrated that our space program stimulates a wide range of technological innovations that find abundant application in the consumer marketplace. Space technology has revolutionized and improved our daily lives in countless ways, and it should continue to do so. Energy from space, advances in solar power and fusion fuels, new useful materials for advanced communications, new resources, medical breakthroughs, and greater insight into the human potential are direct benefits we can expect. *The Space Exploration Initiative provides focused goals to drive practical and beneficial technological change.*

Commercialization of Space. Initiatives by the private sector are goals of our National Space Policy. Space is a limitless, untapped source of materials and energy, awaiting industrial development for the benefit of humanity. *Commercial products, such as zero–gravity–derived materials, and service industries like advanced global communications services, all become increasingly feasible and profitable once routine, reliable and affordable access to space is available.*

Strengthened U.S. Economy. New technologies open new markets. An investment in the high technology needed for space exploration will maintain and improve America's share of the global market and enhance our competitiveness and balance of trade. It will also directly stimulate the scientific and technical employment bases in our country, sectors whose health is vital to our nation's economic security. *The Space Exploration Initiative is an investment in the future of America.*

But, Why Now? As Americans, we must ask ourselves — What will be our role in the future? Will we lead? Will we follow? Or, will we step aside? Leading world powers have always explored and profited greatly from new frontiers. Space is the new frontier of our industrialized world in the 21st Century. The Space Exploration Initiative will restore America to pre–eminence as the world's space leader. By offering both a direction and a purpose, it will rejuvenate our sense of challenge, of competitiveness and of national pride. The Space Exploration Initiative is a positive social endeavor. In a world of uncertainty, it has the capacity to inspire people, to stimulate them, and to cause them to reach deep inside to find the very best they have to offer. *In America's history, our focused, goal–driven initiatives have a spectacular record of success and benefit to all humanity. We must not settle for less in our future.*


ate
uture.”

TECHNOLOGIES FOR SPACE AND FOR EARTH

Since our ancestors first gazed into the skies, the concept of space exploration has fueled the imagination, challenging mankind to understand the unknown, to explore . . . and to learn. In America today, scientific literacy is declining. Our students no longer lead the world in earning degrees in science, engineering and mathematics. For America's future, these trends must be reversed. The Space Exploration Initiative presents challenges and new goals. It will rekindle public interest in science. Once again, space exploration will excite the nation's imagination. It will motivate our educators to teach, and our public and students to learn, and then to innovate.

Technology will provide the tools necessary for cost effective and safe exploration of the Moon and Mars. While the Initiative requires a broad range of technologies, power and transportation are both of primary importance. The safe use of nuclear energy for space propulsion can have the same benefits for space propulsion that jet propulsion had for air travel. Improved solar energy collectors and powerful new lightweight batteries will be vital tools as well. A

conventional heavy lift launch vehicle will be needed to ferry large components and supplies to Earth orbit in preparation for distant voyages. For surface operations, advanced regenerative fuel cells will be critical for landers, rovers and lunar spacecraft.

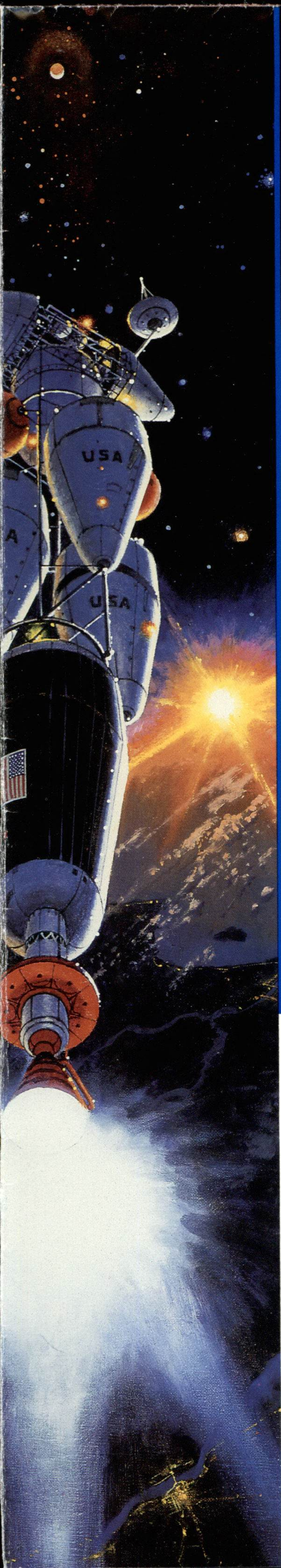
Crews will require air, water and food, along with protection from galactic and solar radiation in space. Recycling of air, food and water will be necessary, leading to improved technology for such purposes on Earth.

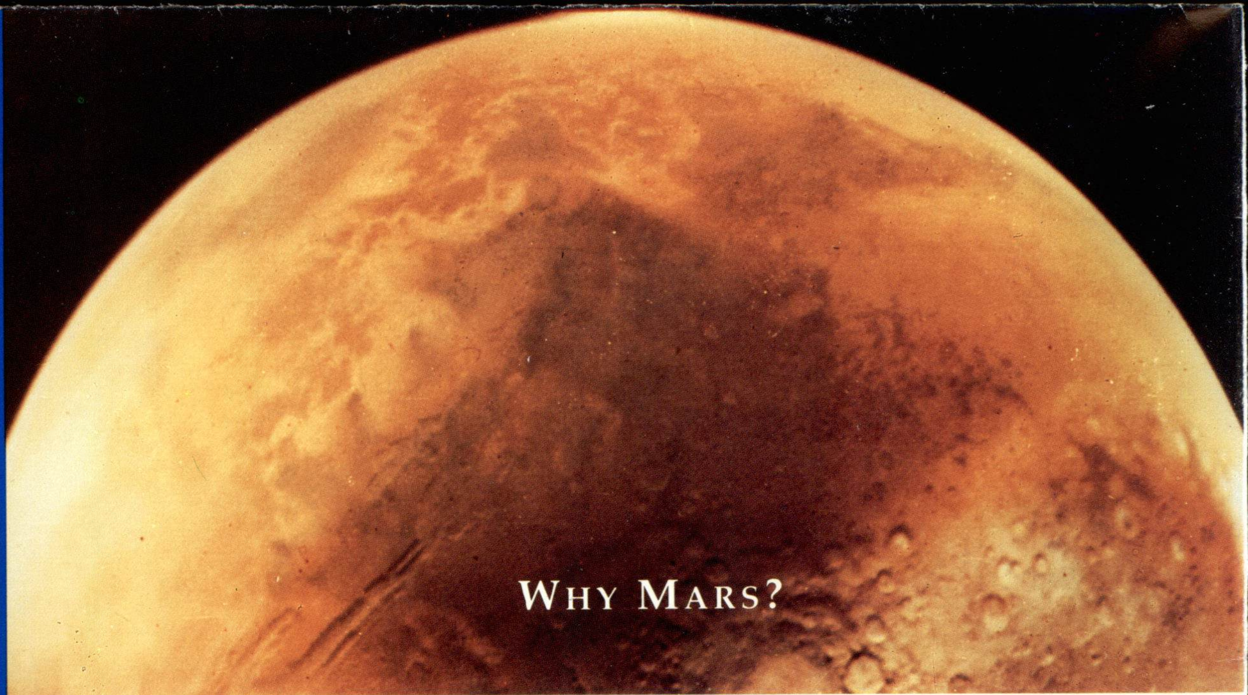
Communication with Earth will be challenging. Spaceflight will require modern, lightweight computers and electronics. Optical communications will enhance operations between Mars, Moon and Earth.

Advanced robotics will be needed to extend the astronauts' range into new locations, such as the polar ice caps of Mars or deep craters of the Moon. The use of video and tactile sensors to control robotic presence will allow exploration without exposing the astronauts to undue risk. Lunar mining and processing equipment will provide resources to supplement those delivered from Earth. We expect to recover rare commodities such as Helium-3 from the Moon for the benefit of Earth.

In Columbus' time, exploring the New World mandated self-reliance. Similarly, independence from Earth's normal support systems will be key to extended living on the Moon and Mars. We must learn to use available resources to generate air, water, food and fuel, as well as to build permanent habitats.

These concepts represent but a few of the many technological advances we expect from the Space Exploration Initiative. Ultimately, we will learn to use the vast resources of space to support and improve life here on Earth. This Initiative will open the Solar System's energy and material resources to relieve the stress on Earth's environment from population growth, and provide our world with limitless resources for the future.





WHY MARS?

Of all the planets in our Solar System, Mars is the most like Earth. With a thin atmosphere, weather, seasons and a 25-hour day, Mars has a diverse and complex surface, including ice and evidence of the former presence of water. Although conditions on Mars may not support life now, evidence suggests that Mars was warmer, wetter, and had a much denser atmosphere early in its history. Life may have existed. If so, fossil evidence may be found.

Mars has undergone a complicated geologic evolution. Its surface contains vast regions of sand dunes, gorges carved by running water, a polar ice cap, huge volcanos and gigantic canyons. Olympus Mons is three times as tall as Mount Everest, and larger than Montana. Valles Marineris is three times as deep and ten times as long as the Grand Canyon. Understanding the periodic changes in climate that have occurred on Mars will enable us to understand the Earth's climate and future behavior, a topic vital to the survival of life on Earth.

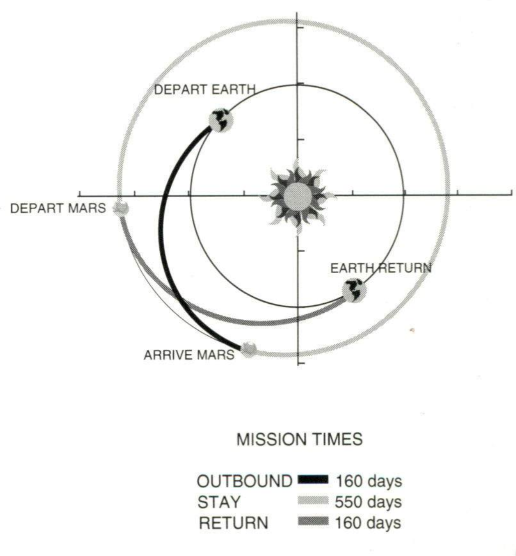
With a land area equal to Earth's, Mars offers an unexplored wealth of natural resources. The essentials for life support, including air and water, can be manufactured on the Martian surface. As Earth's assets dwindle, Mars may offer resources mankind will need.

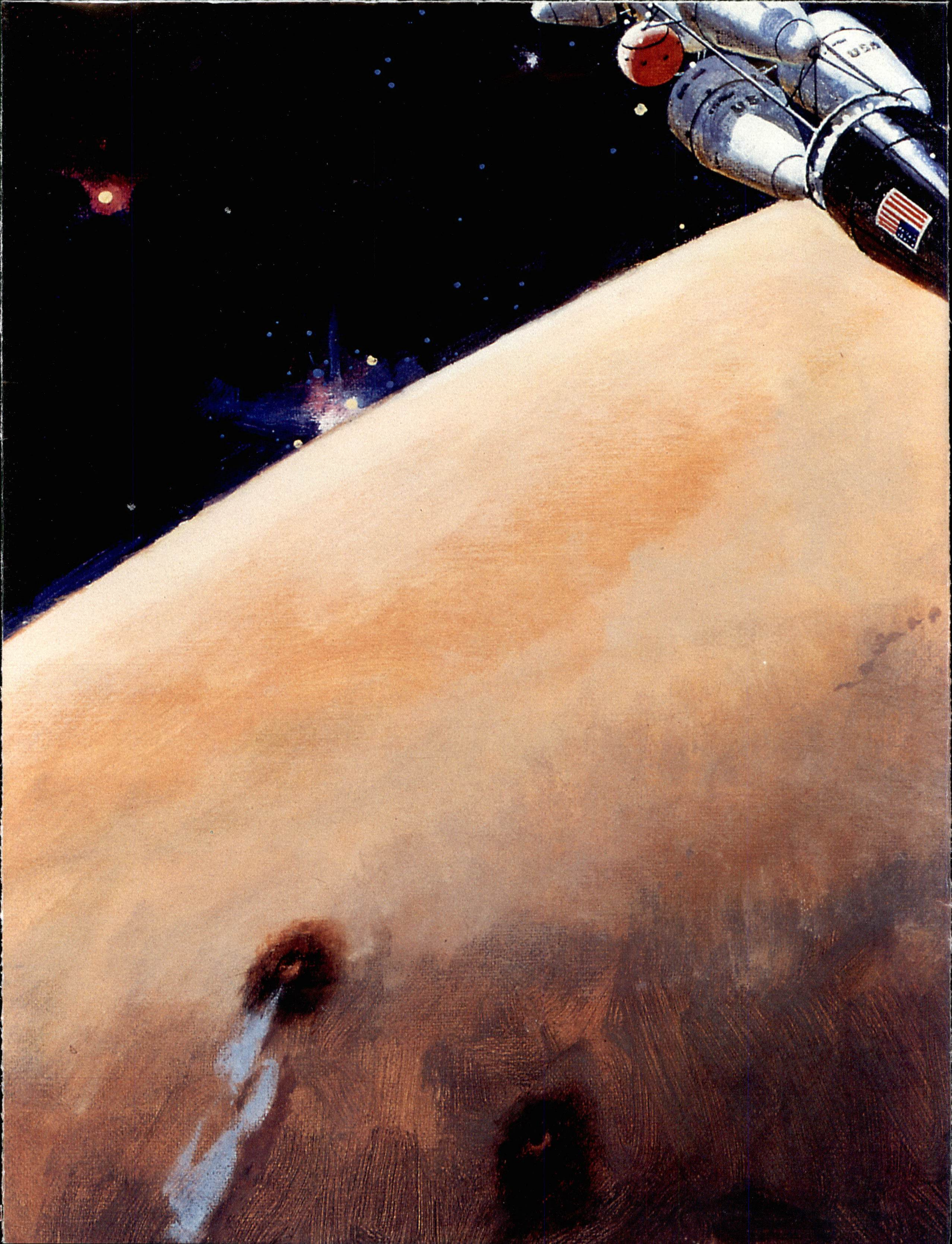
gravity, psychological stress from long term isolation, and equipment degradation.

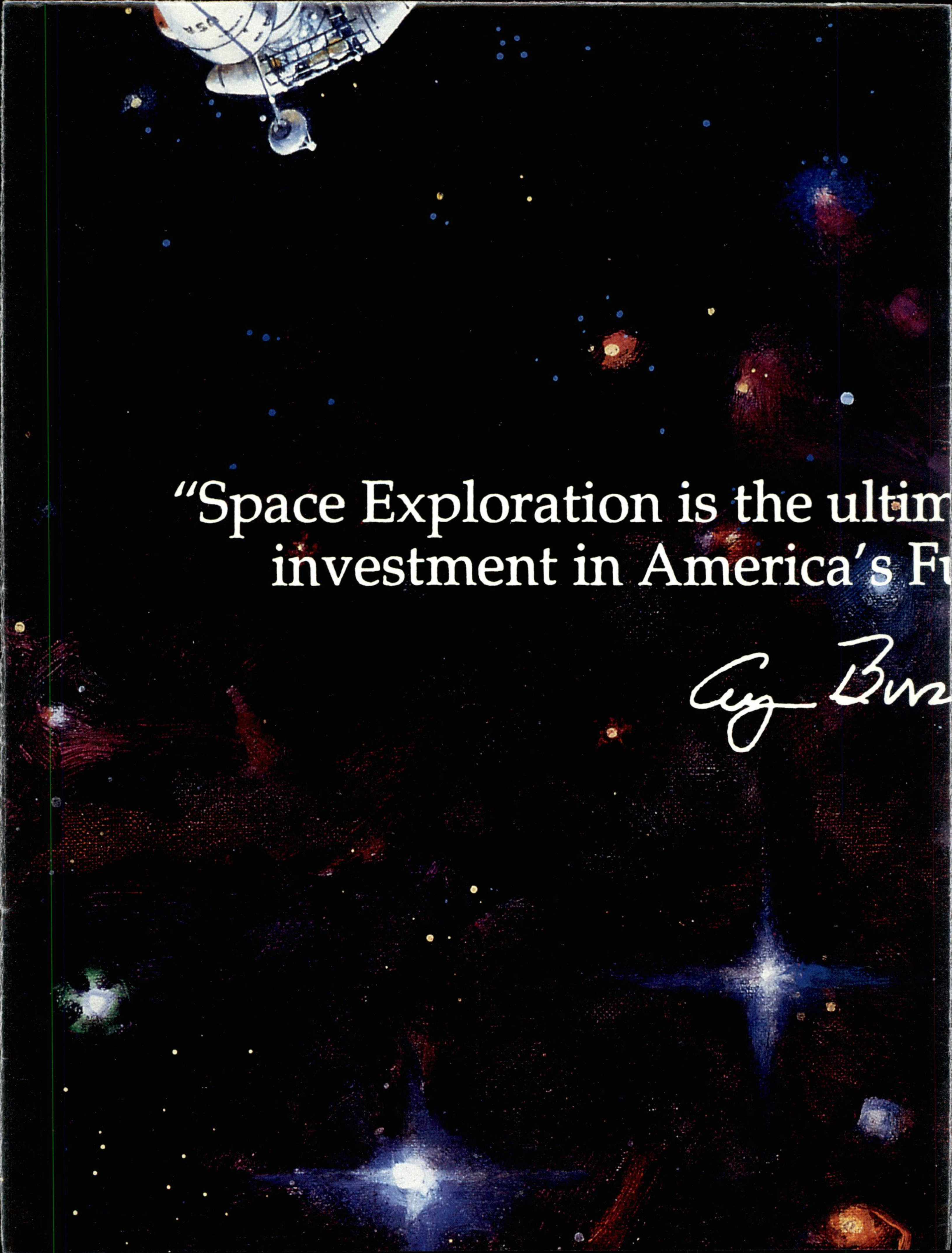
As a result of the challenges of a Mars trip, several hundred tons of equipment and fuel are required for a Mars expedition. Thus, we will require a conventionally powered heavy lift launch capability to minimize assembly in Earth orbit. From Earth orbit to Mars, nuclear propulsion technology will allow reduced weight, approximately one-half that of chemical systems, and achieve faster interplanetary trip times. At Mars, we will need Earth-independent operations, since round trip communications times will vary from 10 to 40 minutes. We will need improved long-term life support systems that operate for lengthy time periods without resupply.

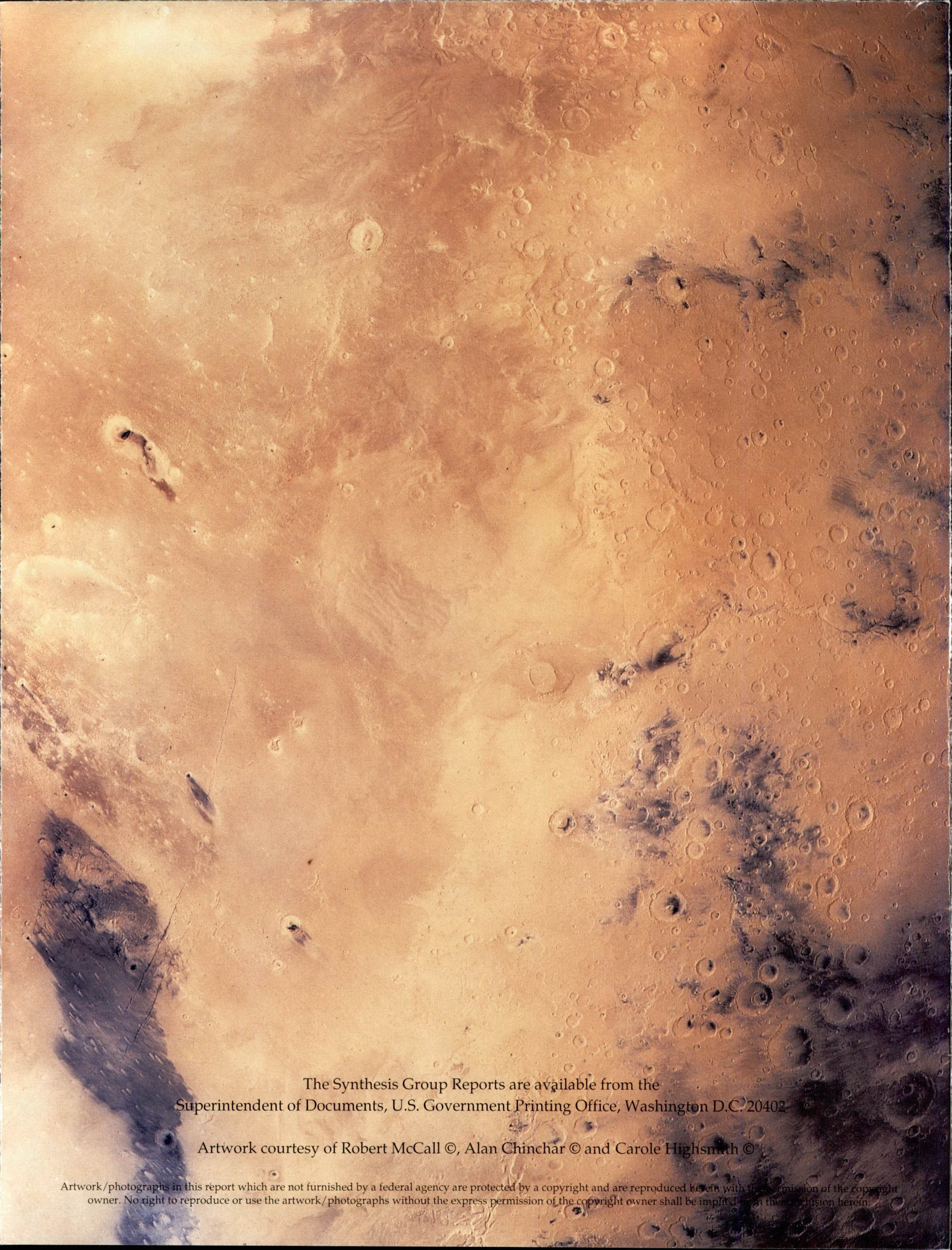
The planetary surface of Mars provides challenges different from those of the Moon. The planet is large — about one-third the size of Earth. It has a diverse topography, with 80,000-foot volcanos and canyons as long as our continent is wide. Mars' atmosphere is mostly carbon dioxide and is known to have periodic dust storms. These features will require unique power systems, landers, rover vehicles and human habitats.

TYPICAL NUCLEAR PROPULSION MISSION
TOTAL MISSION: 870 DAYS
2014-SHORTENED TRANSIT





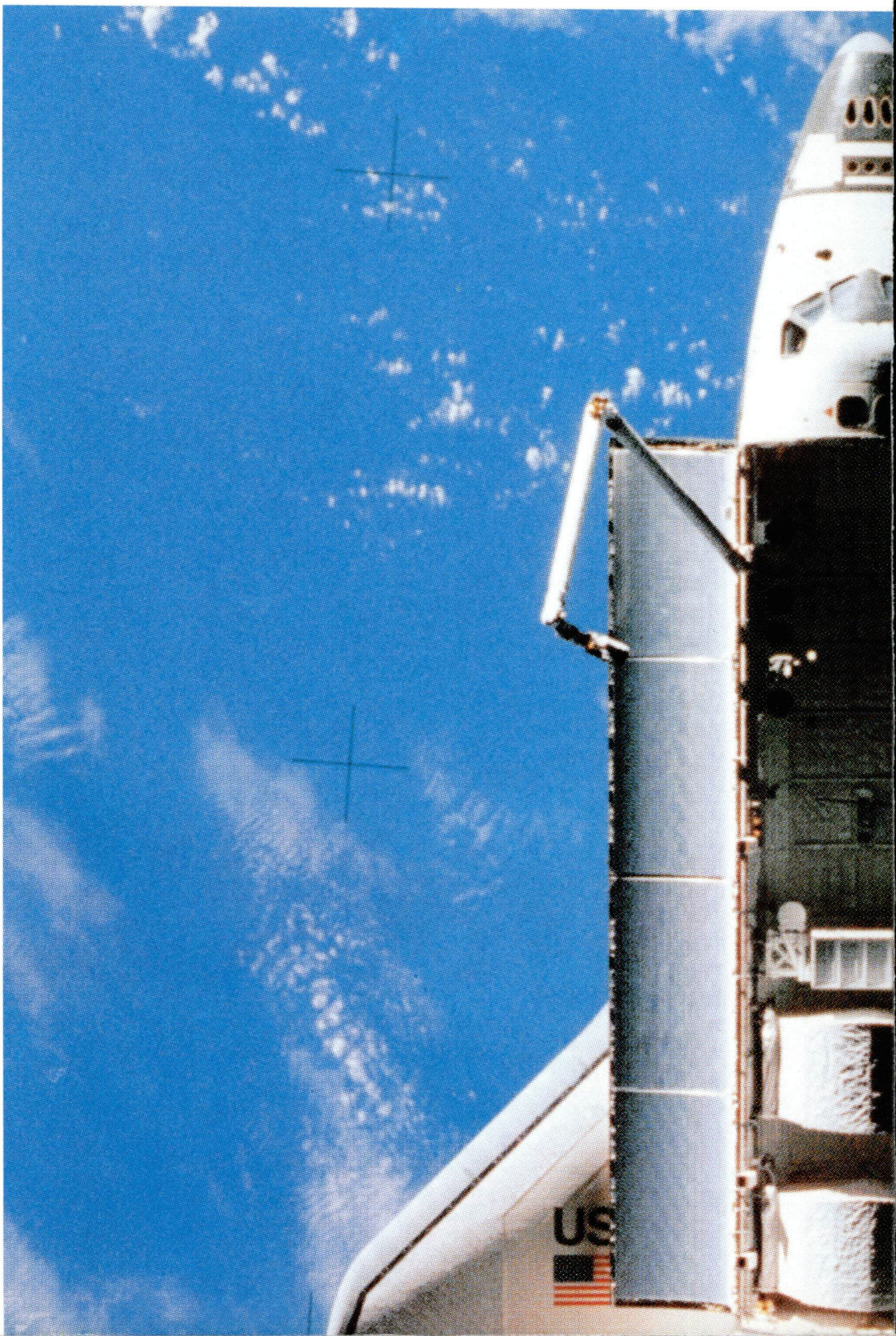

“Space Exploration is the ultim
investment in America’s Fu

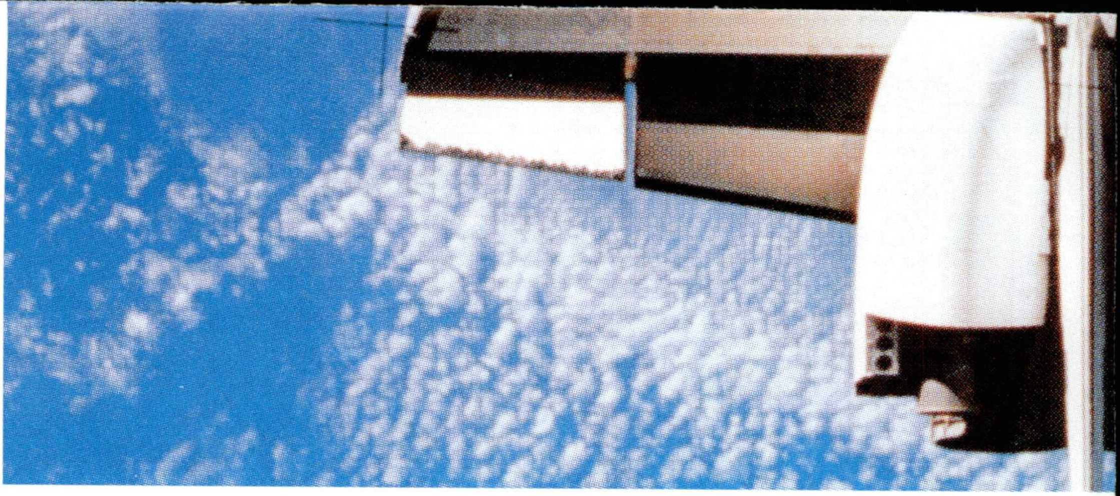


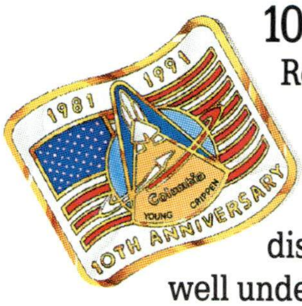
The Synthesis Group Reports are available from the
Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402

Artwork courtesy of Robert McCall ©, Alan Chinchar © and Carole Highsmith ©

What we learned fron
was just the beginnin







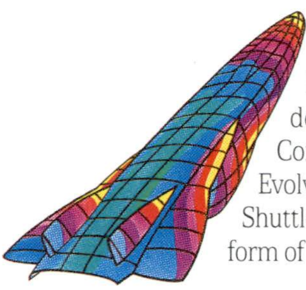
10 years ago, as Rockwell International readied NASA's Space Shuttle for its first launch, a voyage of discovery was already well under way.

When *Columbia* soared into space on April 12, 1981, its launch opened a limitless frontier—fulfilling the age-old dream of a spaceship that can fly time after time. One decade later, the Shuttle fleet has launched 41 percent of all the mass ever placed in orbit by humans. Yet its missions total just 4 percent of all spaceflights.

The Shuttle has carried more than 500 experiments that benefit Earth-based processes. It's brought home the rewards of space more frequently than any manned vehicle in history. Through the work of thousands of people at Rockwell, its hundreds of subcontractors and NASA, these achievements are building a legacy that will affect us all well into the 21st century.

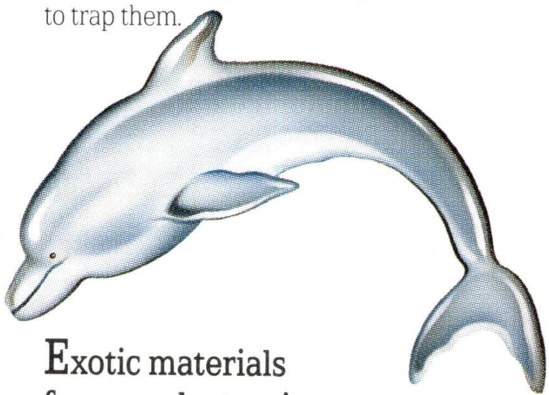
Software that gives tomorrow's aircraft a flying start.

Intended to travel at nearly 17,000 mph, America's National Aero-Space Plane is part of today's race for technological leadership. Refining its aerodynamics depends on a science called Computational Fluid Dynamics. Evolved by Rockwell during the Shuttle's design phase, this advanced form of computer simulation now plays a key role in the development of military and commercial aircraft.



Fishing nets that let dolphins go free.

As a tuna net encircles its catch, a dolphin rises seeking an escape. Its passage to freedom is aided by a technique developed while fabricating safety nets for workers maintaining the Shuttle. Using a new rope that grows much heavier in water, tuna nets sink deeper and resist forming hazardous pockets. So dolphins swim more safely until escaping over a special mesh panel too fine to trap them.



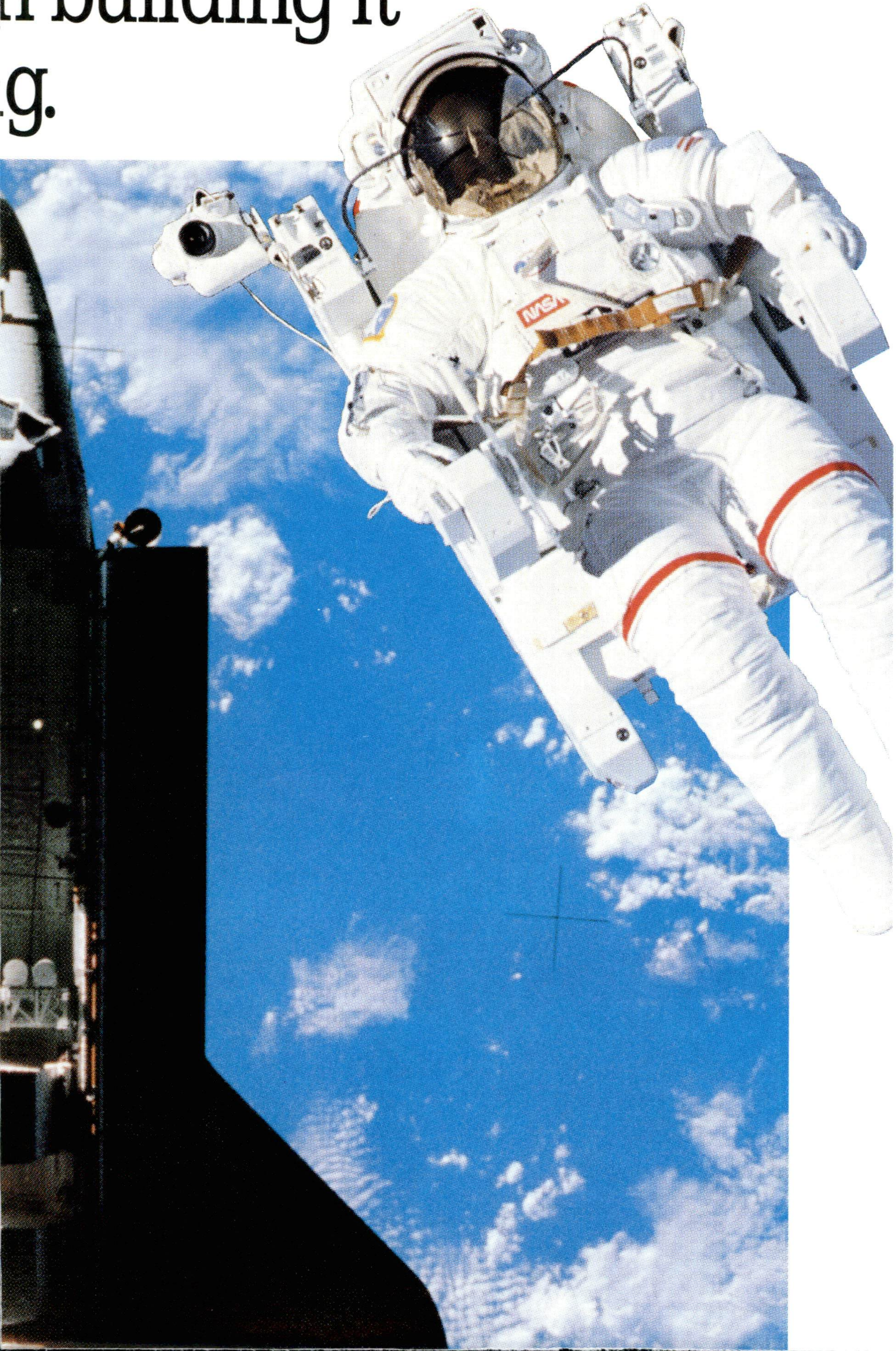
Exotic materials for new electronics.

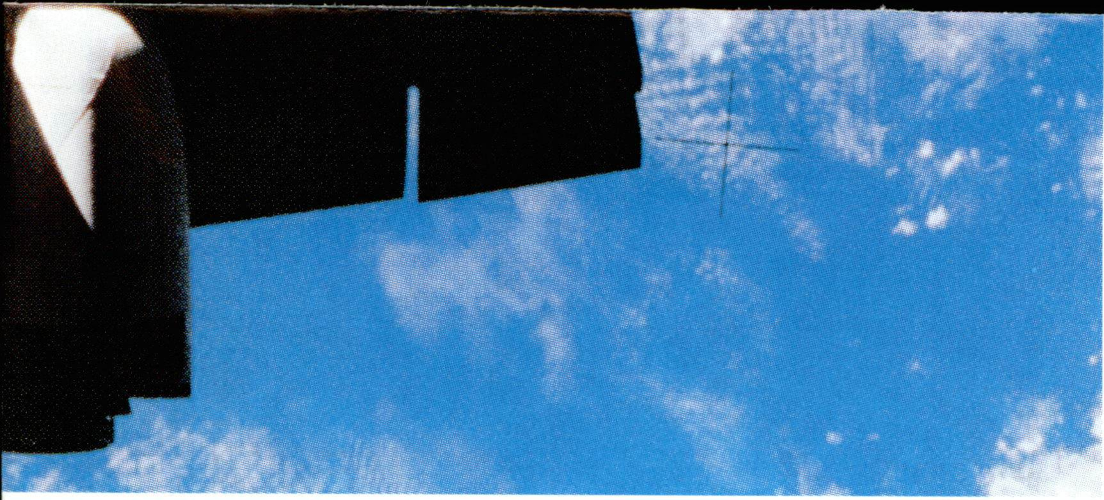
A voice translator that slips in your pocket? Lightweight night-vision glasses that guide sailors to safety? Tomorrow's electronic breakthroughs will rely on ever faster and less power-hungry circuits. Aboard the Shuttle, the Rockwell materials processing lab has permitted advanced materials research directed toward the manufacture of such advanced chips.

Tools to combat oil spills.

As oil spread into Alaskan waters from a ruptured supertanker, authorities rushed

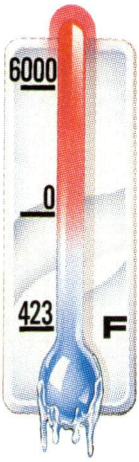
n building it
.g.





a network of inflatable barriers to the scene. Designed to contain the oil for burning, each barrier was sheathed in a material used to protect the Shuttle against the fierce heat of reentry. Rockwell's experience fabricating this insulation helped speed its adoption by pollution-control specialists.

Engines that go to extremes.



When all three ignite at launch, Rockwell's Space Shuttle Main Engines unleash the power of 23 Hoover Dams. Building the most powerful liquid-fueled rockets in history meant creating hardware suited to unprecedented temperature extremes: from the −423° F of liquid hydrogen fuel, to exhaust at +6,000° F, above the boiling point of iron.

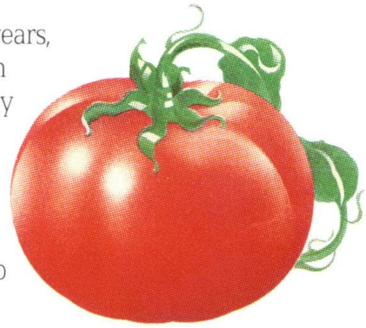
Finding facts that fight disease.

The diagnosis was unclear. But by tapping a vast medical database with her PC, the physician scanned years of medical literature to identify a rare condition in minutes. Such instant access to information in science, government and business is an outgrowth of lessons in database management Rockwell learned while managing the vast number of parts, specifications and subcontractors involved in the Shuttle program.

Giving satellites a second chance.

A control-system failure left NASA's Solar Max satellite unable to study the sun. Then repairs performed by astronauts on board the Shuttle returned this valuable space observatory to action—just in time to record an historic solar flare. The Shuttle's ability to deploy and recover spacecraft such as Solar Max and the Hubble Space Telescope helps ensure that these tools for studying the Earth and the universe can fulfill their potential for exploration.

Bringing space within reach of us all.



After orbiting for nearly six years, a container holding 12 million tomato seeds was retrieved by a Shuttle crew. Distributed to a million schoolchildren for experiments, the seeds exemplify how the Orbiter's frequent flights open space to researchers of all kinds.

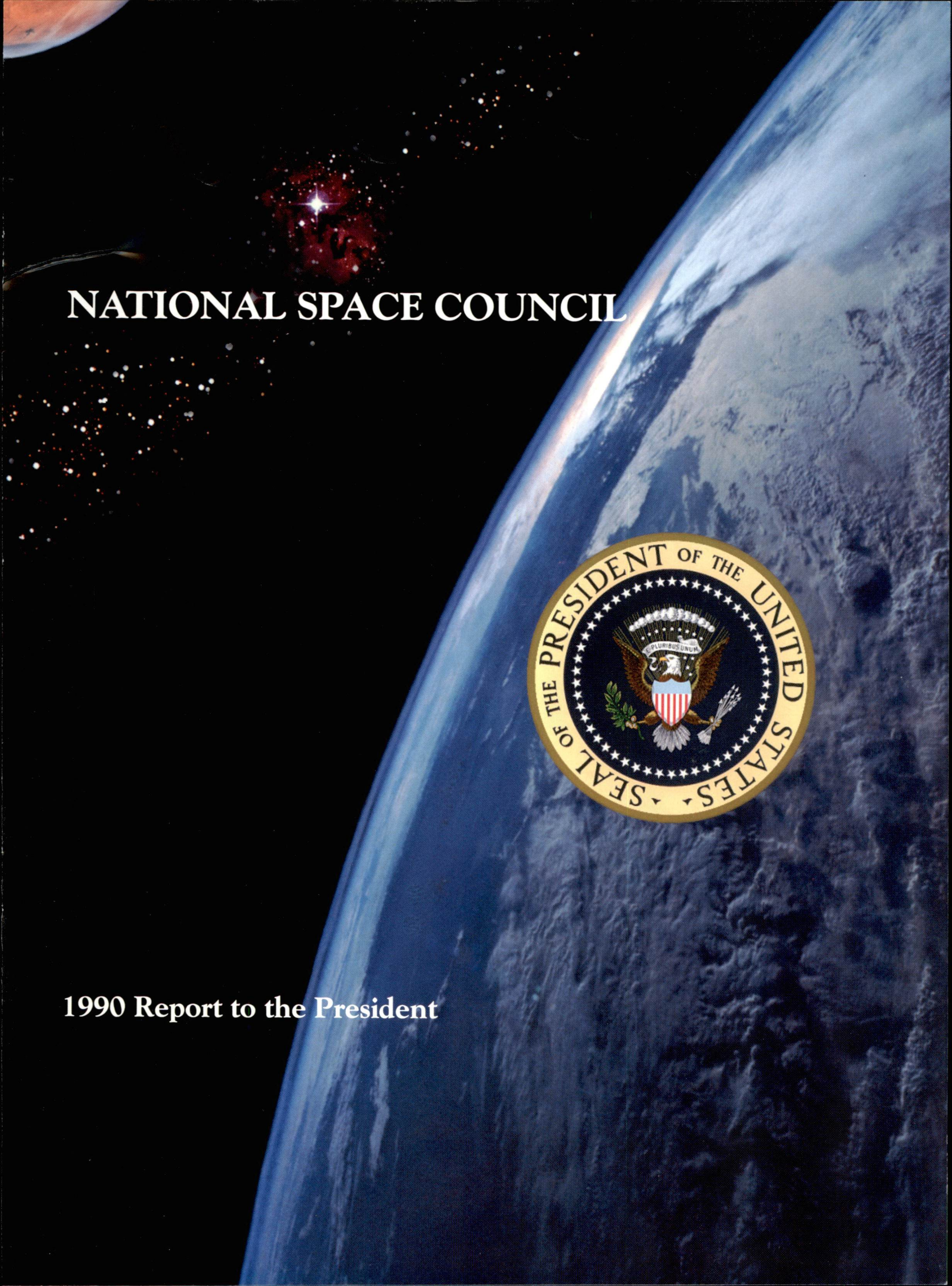
What we've seen so far is just the beginning.

These achievements are simply a glimpse of what's to come. As with any voyage of exploration, the most astounding and beneficial discoveries are those we cannot predict. As we move into the second decade of Shuttle flights, we look forward to a growing portfolio of such successes. They are the dividends we all receive for investing our support in the future of manned spaceflight.

Rockwell International

YOUNG ASTRONAUTS™ USA

NATIONAL SPACE COUNCIL



1990 Report to the President

SEAL OF THE PRESIDENT OF THE UNITED STATES

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

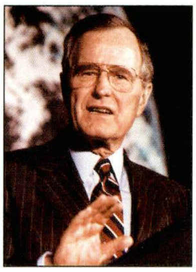
Space, like the oceans, is a medium of travel, an as-yet unexploited repository of natural resources, and a strategically useful domain. To protect the freedom of space we must be able to do three things: First, we must be able to see and monitor all that occurs in space. Second, we must be able to alert 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.

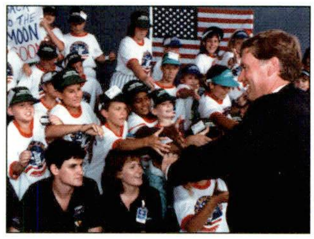
In conclusion, we have begun developing strategies for implementing a sound program of achievement in each of these five areas. Our efforts in each case are guided by our belief that a broadly-based, cooperative effort involving the national security, civil, and commercial space sectors is the only sure 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 commit-ment 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.

Contents





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.

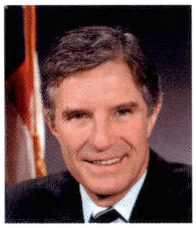
The National Space Council is supported by an Executive Secretary appointed by the President. The first Executive Secretary of the Council, Mark Albrecht, leads an eleven-member policy staff. The Council is further supported by a sub-cabinet-level interagency Policy Implementation and Review Committee (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.

Vice President

Secretary of State

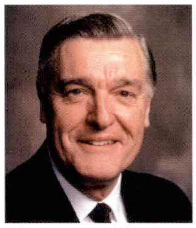
Secretary of the Treasury

Secretary of Defense



Secretary of Commerce

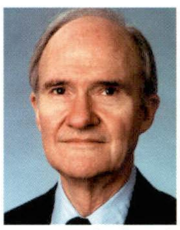
Secretary of Transportation



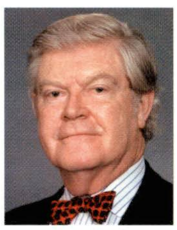
Secretary of Energy

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

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.

Executive Secretary Mark Albrecht

"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."

"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."

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 communications 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."

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.

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 NATION

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.

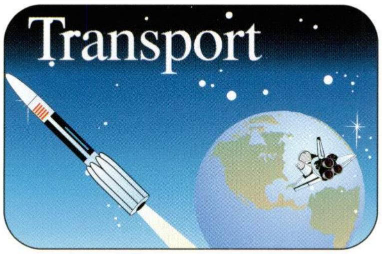
ACE STRATEGY

Key Elements of National Space Strategy

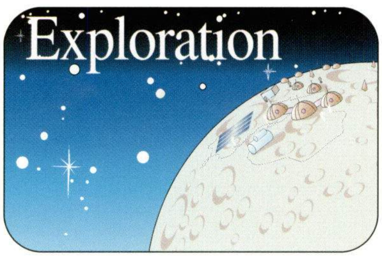
The Space Council's approach for implementing U.S. national space policy divides all space activities into five areas, each of which may encompass civil, national security, and commercial activities conducted by NASA, DOD, DOE, DOT, other government agencies, or the private sector.

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.



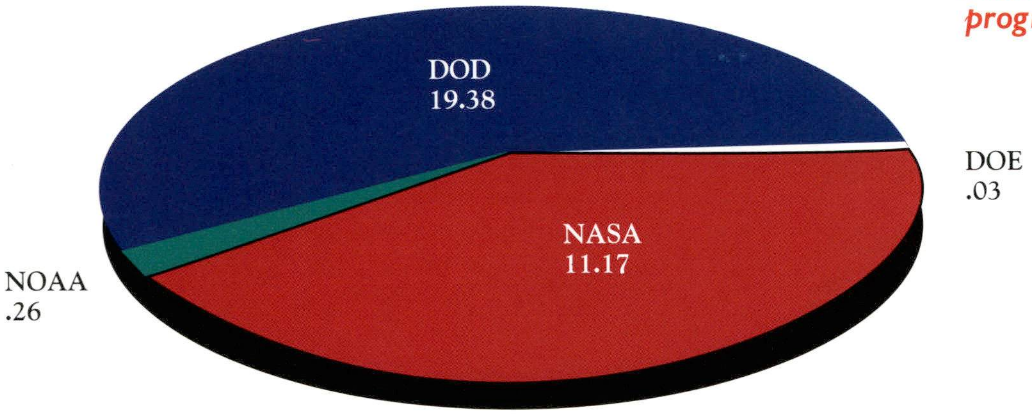
2 To open the frontiers of space through both manned and unmanned exploration: we will build on the successes of Viking and Voyager and proceed to comprehensively explore the solar system with Magellan, Hubble, Ulysses, and other ambitious unmanned programs. The President's call to complete Space Station 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.

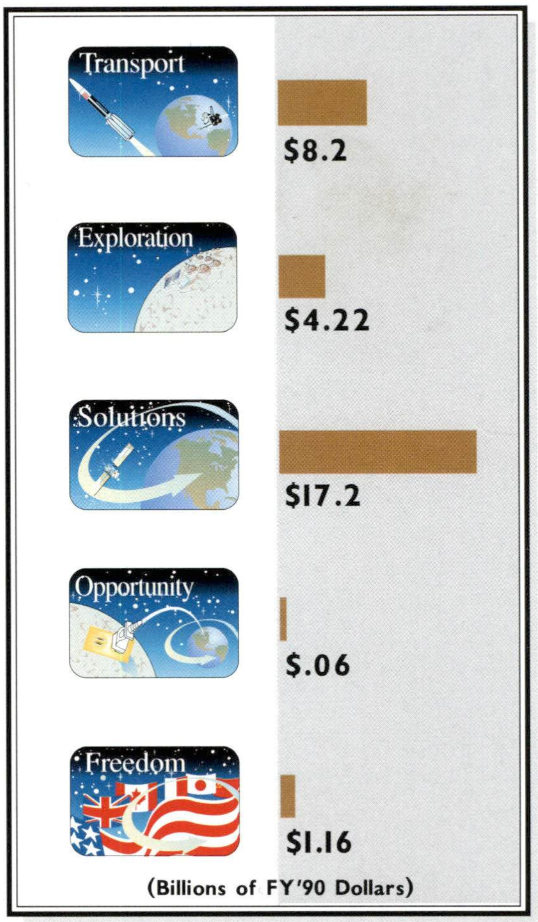
The Council's strategy is designed to achieve these objectives as an integrated national effort cutting across traditional lines of civil, military and commercial programs.

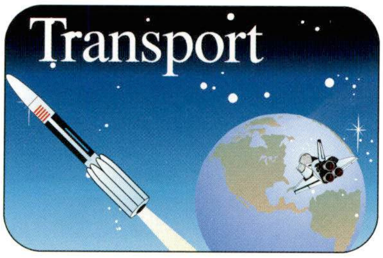


Resources for Space

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

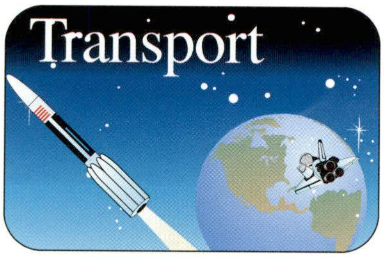
We are already embarked on what many scientists call the renaissance of scientific space exploration.

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

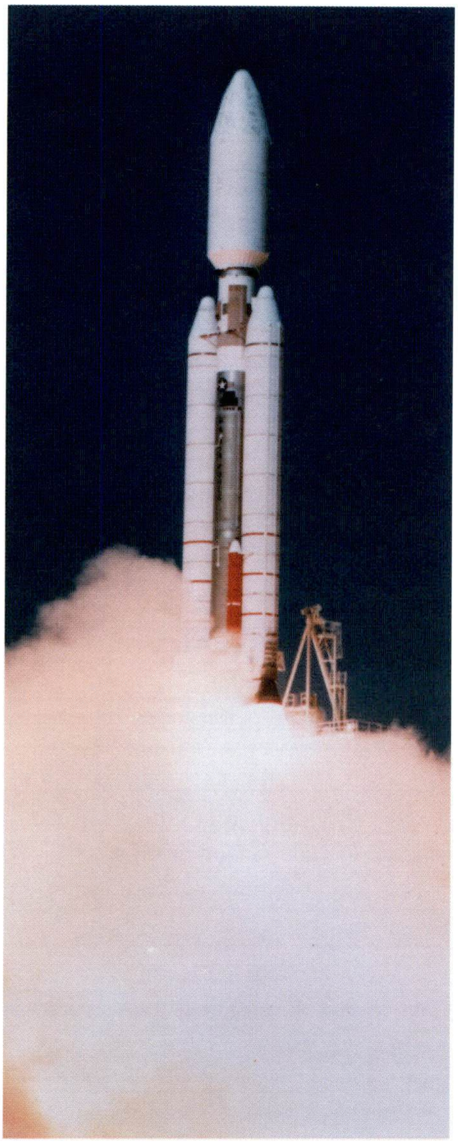
The Space Council recently completed a comprehensive review of commercial space launching which resulted in important new policy guidelines which will further encourage the growth of U.S. private sector space activities.

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.

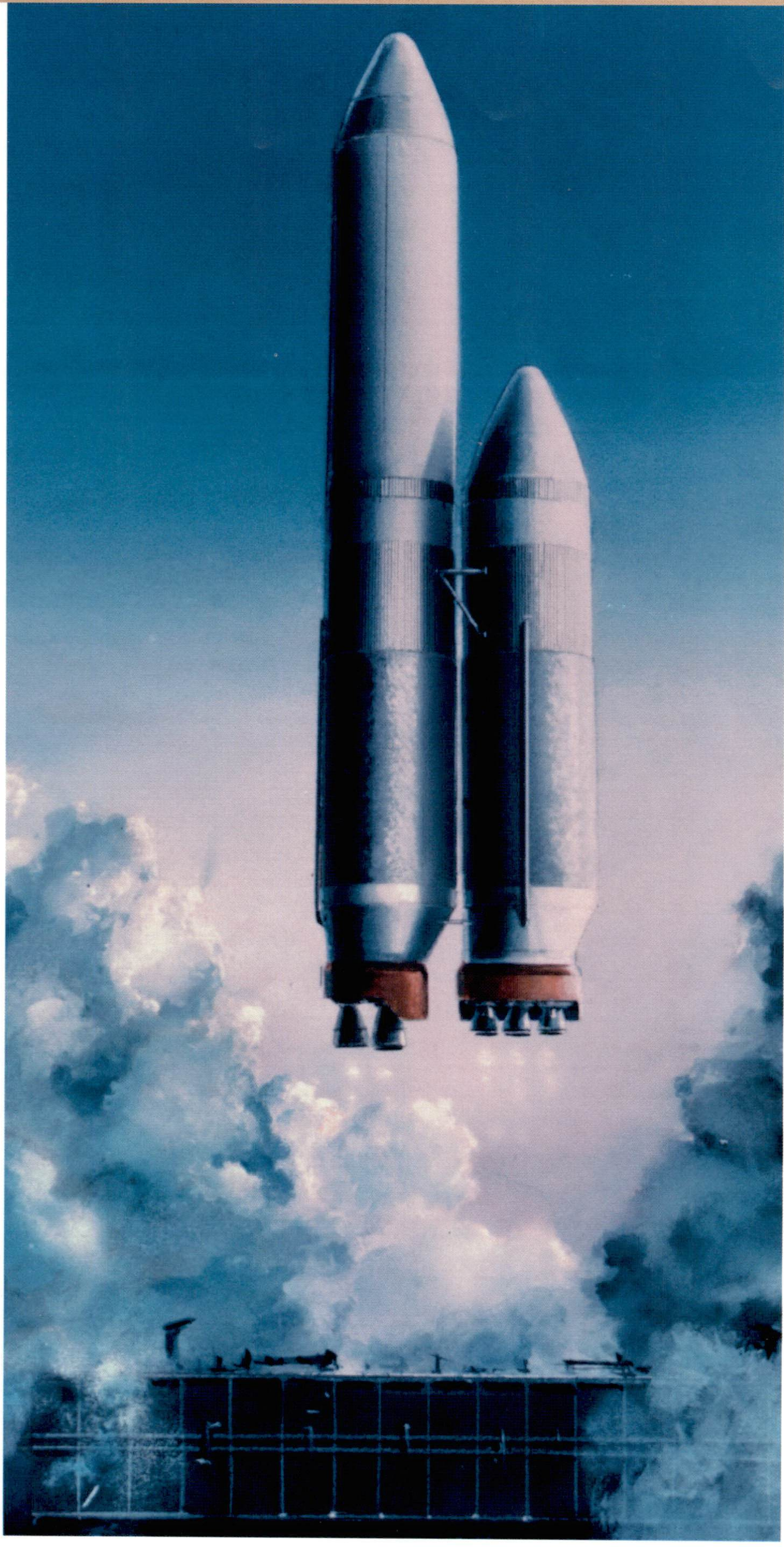
The policy specifies a coordinated set of actions for the next ten years aimed at achieving this goal. The elements of the policy will:

- 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.

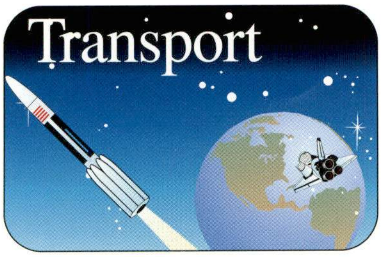
The Titan launch vehicle



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

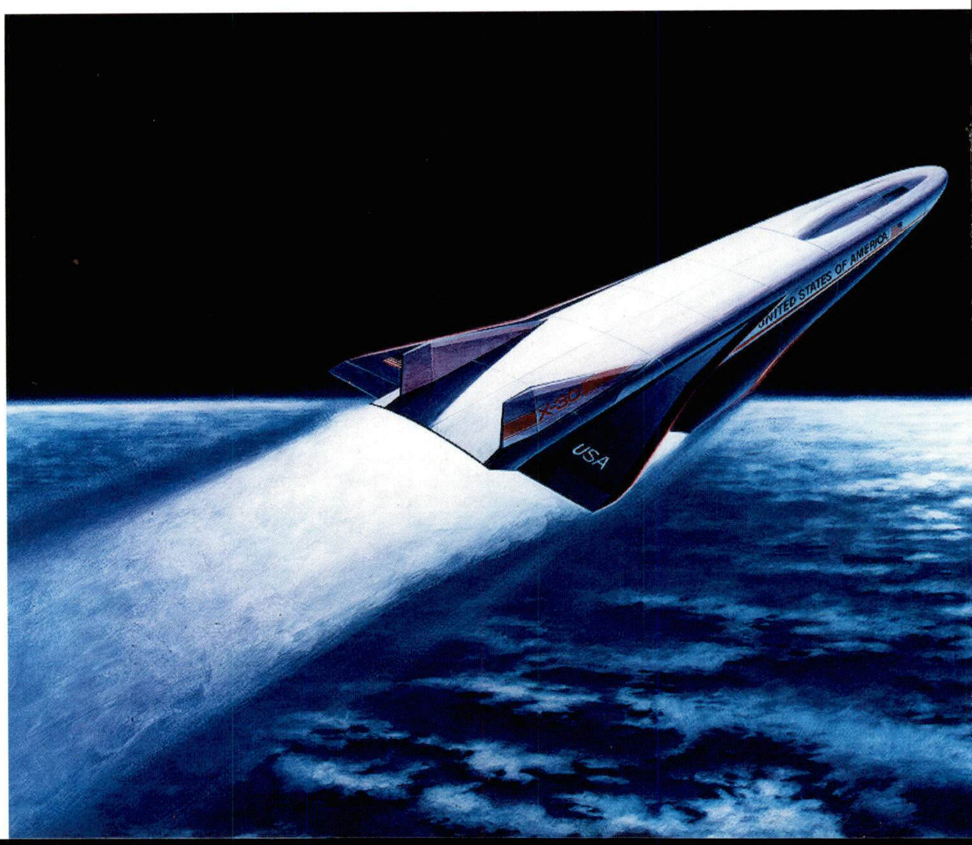
In April 1989, the Secretary of Defense, in developing his revised budget, asked the National Space Council to review the NASP program.

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



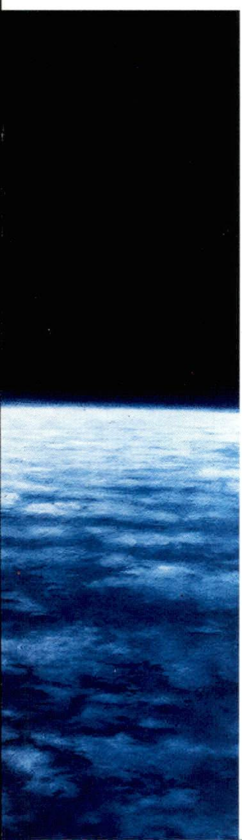
remains a technically challenging program and that its technology is not yet sufficiently mature to support a decision to proceed with operational vehicle design and development.

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."

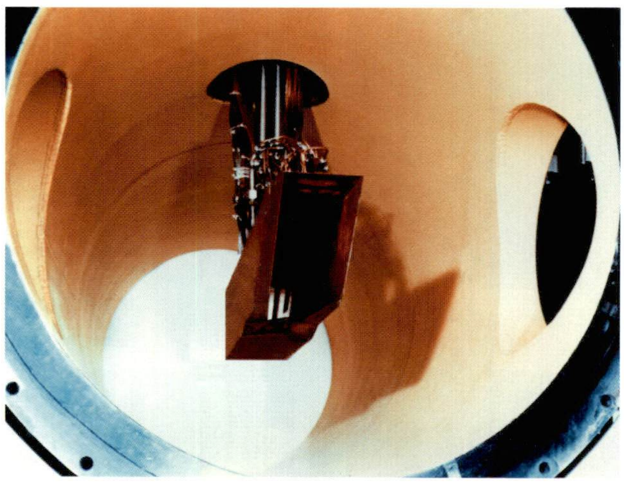
The President also approved retention of an appropriate joint DOD/NASA management structure, and asked the Space Council to review the program again prior to initiation of vehicle development. These actions set the NASP program on a sound course consistent with national policy objectives. He also directed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

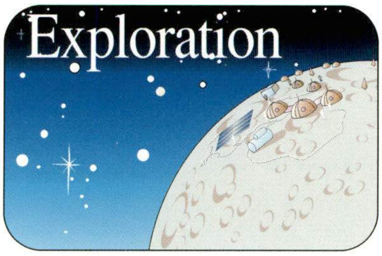
Titanium composite material fabrication



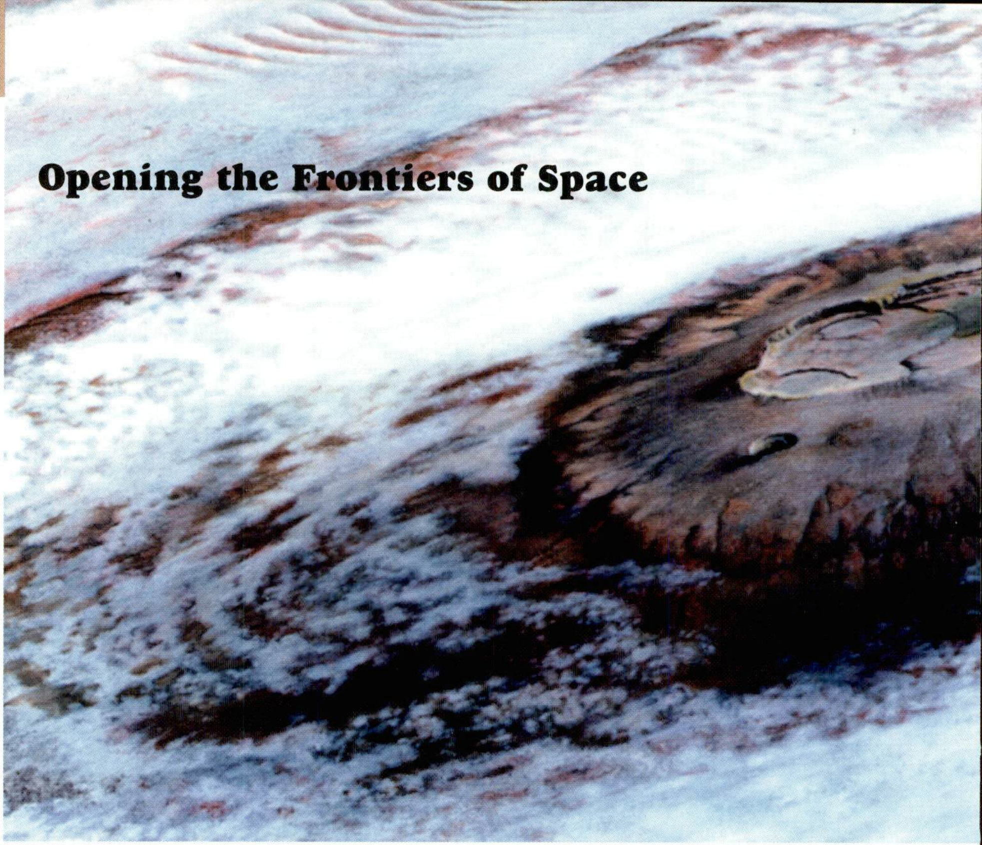
Concept of the NASP experimental prototype

Supersonic combustion Ramjet Engine test

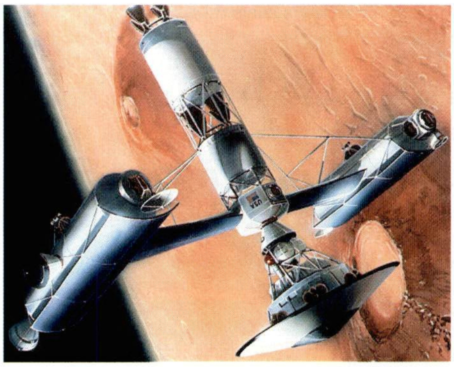


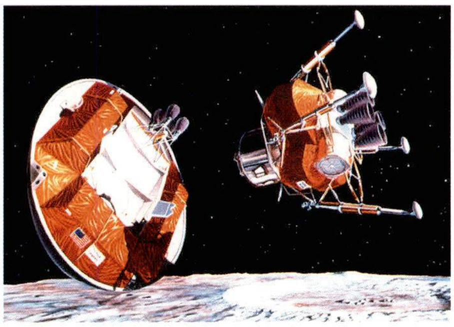


The Space Exploration Initiative is the ultimate investment in America's future.



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.

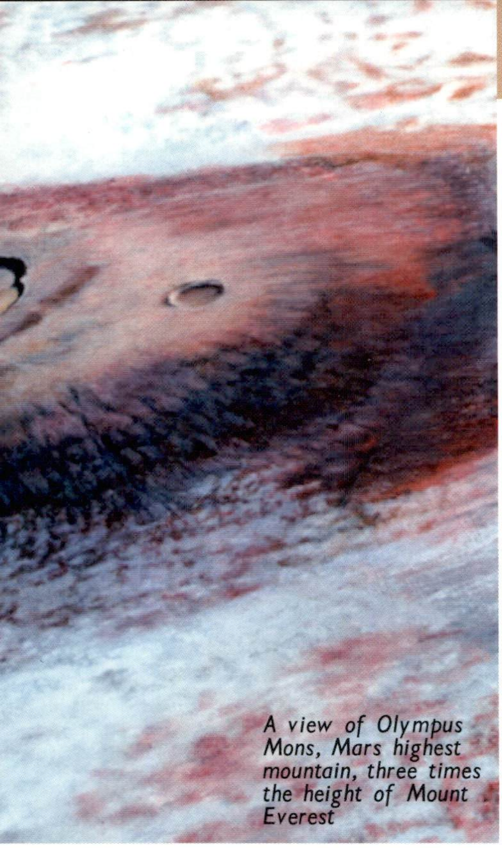
Various detailed programs for permanent settlement of the Moon and the human exploration of Mars have been proposed for over 20 years as logical extensions of the capabilities we developed for Apollo and subsequent Earth-orbit operations.

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.

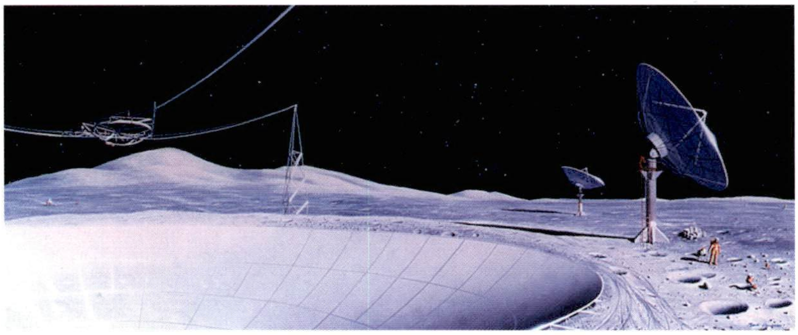
The Space Council was charged by the President to define an approach by which his space exploration goals could be best achieved, including an assessment of the possibilities for international cooperation.

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


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

The Council recommended 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.

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



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.

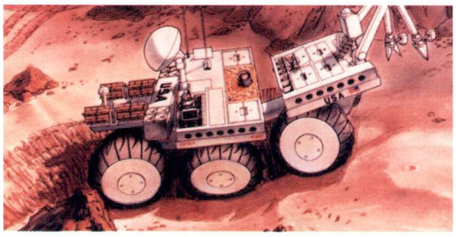
The decision also stated that the initiative be led by NASA and include a balanced program of robotic and manned exploration missions. To take maximum advantage of existing capabilities, however, the technological and systems expertise of other relevant agencies should be tapped. Therefore, the Departments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

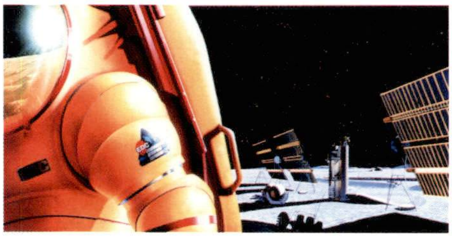
The ideas collected by the Outreach effort are being reviewed and analyzed by a Synthesis Group chaired by Lieutenant General Tom Stafford (Ret.), former Apollo astronaut and distinguished space expert. This panel will report to the NASA Administrator and the Space Council in early 1991—recommending the alternative architectures and technology development course we should pursue over the next few years.

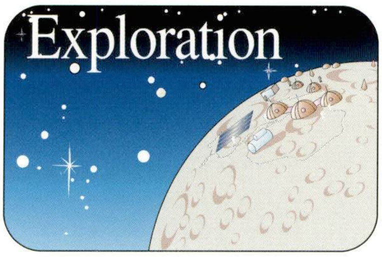
The Synthesis Group recommendations and the work to study the alternative architectures in the coming few years can shape the heart of our exploration effort. While we are not embarking on a costly development program now, these efforts will allow us to make informed decisions on how and when to proceed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

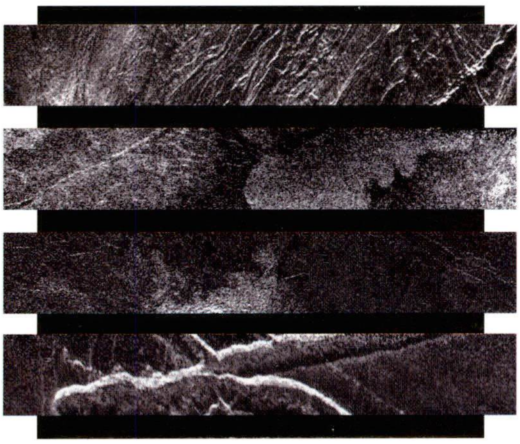
Freedom will provide a world-class multidisciplinary laboratory in space for life sciences and materials research which simply cannot be done on Earth. It will support instruments to look out at the universe and back at the Earth, including those which will help us understand the threats to Earth's global 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.

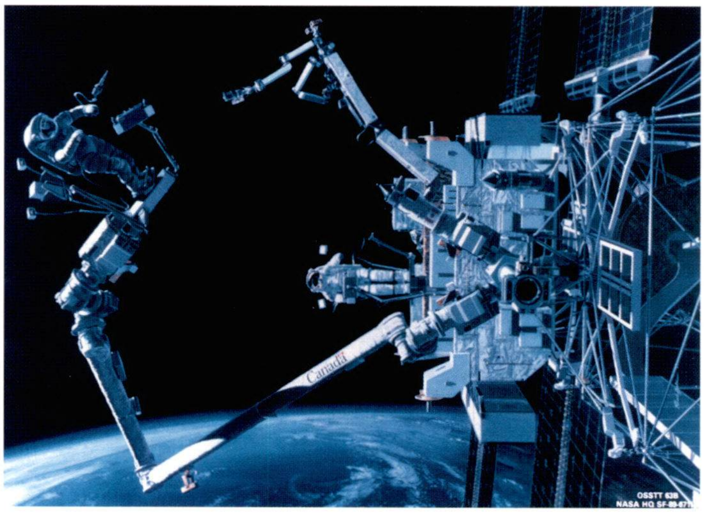
In summary, Freedom will be an important element in opening the frontiers of space, in attracting new private-sector users of space in such industries as advanced materials and medical products, and in forging closer bonds with our international partners.

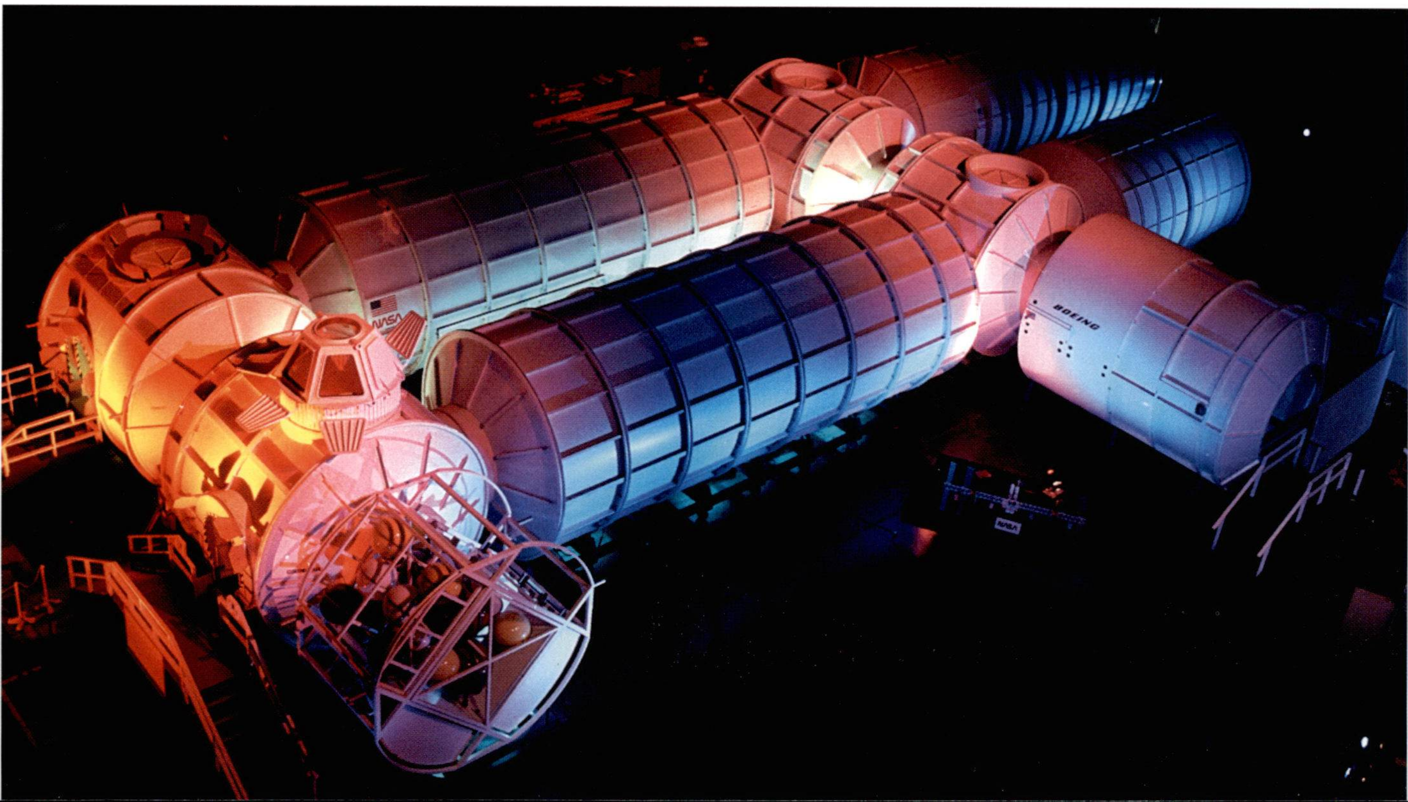


Images of Venus from Magellan spacecraft

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.



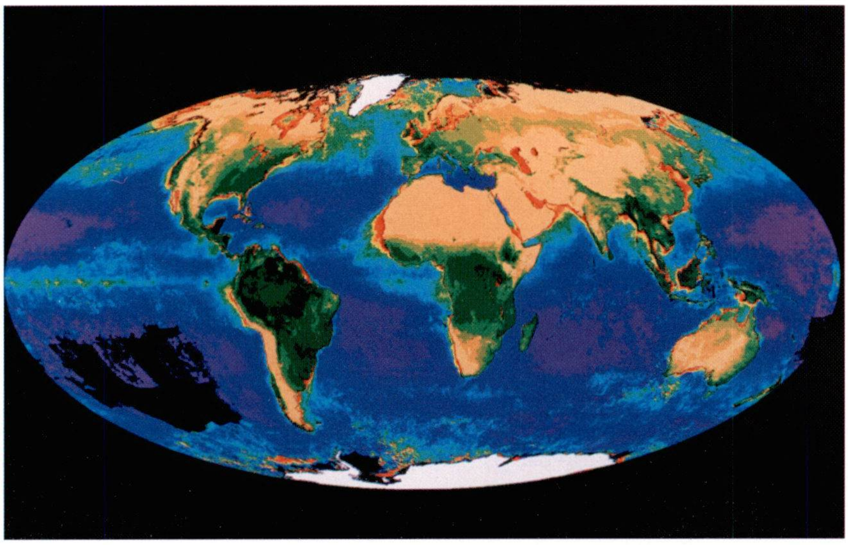


Using Space to Solve Problems on Earth

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, transoceanic 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

Using Space to Solve Problems on Earth

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

Microgravity Science

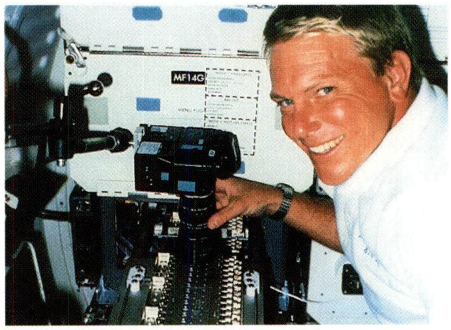
Microgravity research is aimed at attaining a structured understanding of gravity-dependent physical phenomena in areas such as materials science, combustion science, and biotechnology. Ultimately, microgravity research may lead to our improving solid-state electronics and semiconductors, developing 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.

Understanding how to grow food in a closed environment

The Landsat Policy Decision

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

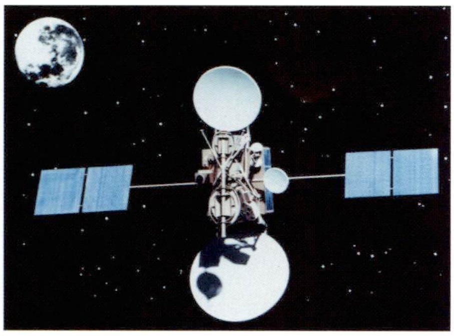
NASA pioneered civil Earth remote sensing with an Earth Resources Technology Satellite launched in 1972 (later renamed Landsat 1). Subsequent Landsats demonstrated this technology and its applications so successfully that it was declared to be operational, and program management was transferred from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

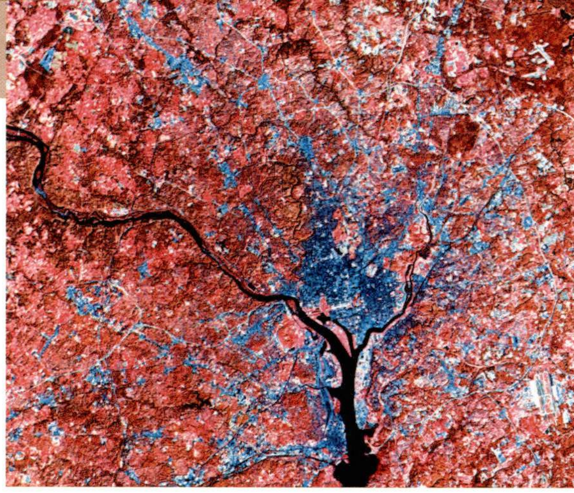


During the past few years, however, it became increasingly evident that privatizing Landsat would not be commercially feasible for a long time. Actual market experience discredited the unrealistic revenue expectations on which previous studies had been based. But since government planning was predicated 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 unequivocably recognized.

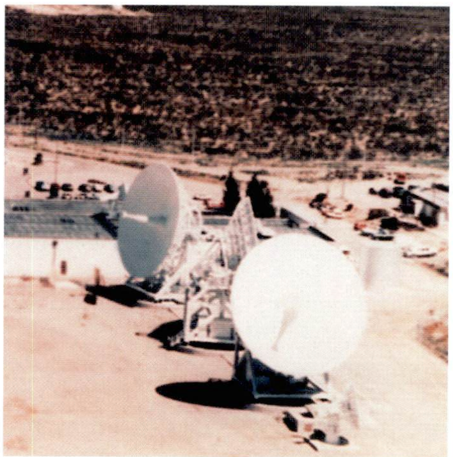
Space Systems are a major source of missile early warning for the nation and its strategic forces and also support tactical operations worldwide. Satellite-derived information also forms the cornerstone of U.S./U.S.S.R. arms-control treaty monitoring, and contributes to global stability by reducing the possibility of surprise developments, thereby allowing time for crises to be averted.

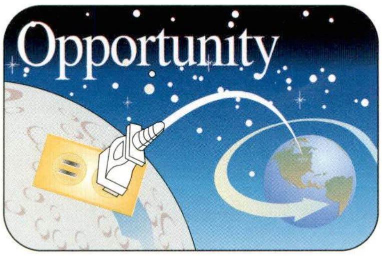
Satellite communications and navigation have become an integral part of every kind of military mission. The worldwide coverage needs of military functions make them ideally suited for support by space systems. The navigation capability established for the military is also used routinely and widely in 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.

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

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.





Generating Economic Well-Being

Creating New Industrial Capability and Jobs

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

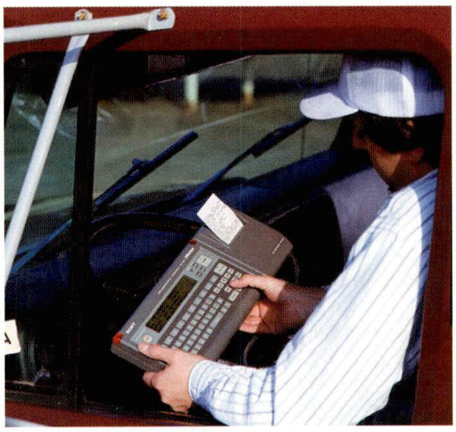
The emergence of a separate, non-governmental commercial space sector, whose importance is explicitly recognized by the National Space Policy, holds the promise of generating enormous benefits for the nation. Already, according to the latest edition of U.S. Industrial Outlook, 1990, "...commercial space 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

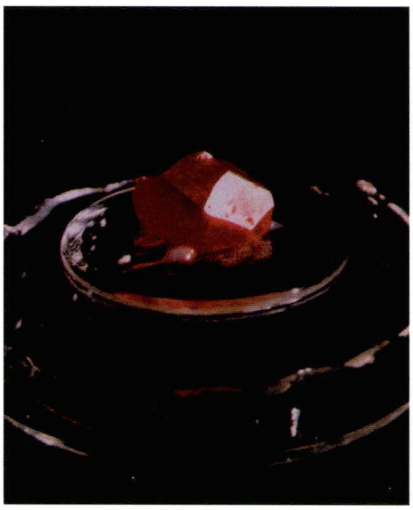
The second largest commercial space sector is in spacecraft launch services. For the period of 1990-1993, the Department of Transportation's Office of Commercial Space Transportation — which licenses and promotes commercial space transportation activities — estimates that the U.S. launch service industry 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.

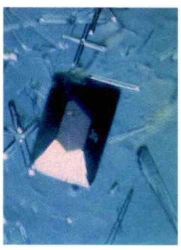
The government contributes to the space economy by being a customer for private-sector goods and services. Because of their often unique or demanding requirements, government purchases can stimulate expansion of the market and the industry, thus creating jobs and generating revenue. An excellent current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

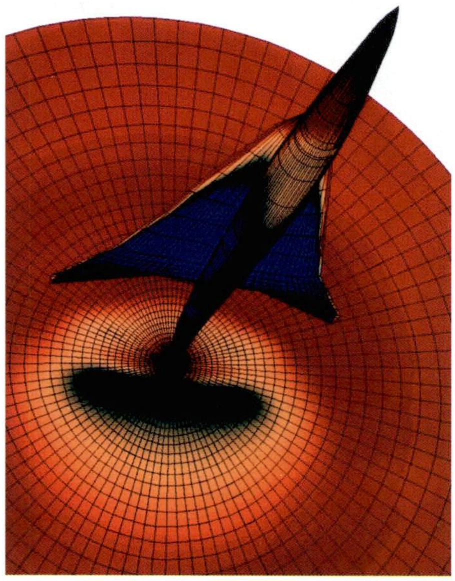
For the long-term no one can predict which industries will emerge from our space efforts. However, we might get our energy from space, find and extract resources, manufacture medical products and treatments to cure dreaded diseases, and produce materials using the unique attributes of space. There is 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

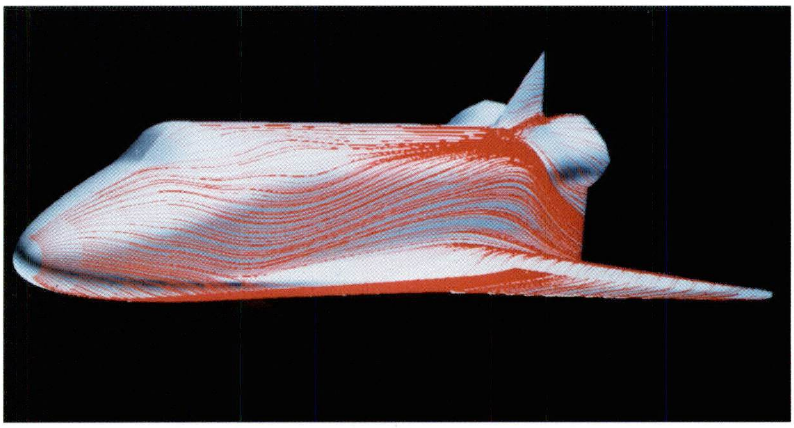
The National Space Council is conducting a comprehensive policy review to develop guidelines to most effectively encourage federal government efforts to support commercial space sector activities. The goal of these guidelines is to minimize unfair competition between the government and the emerging commercial 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

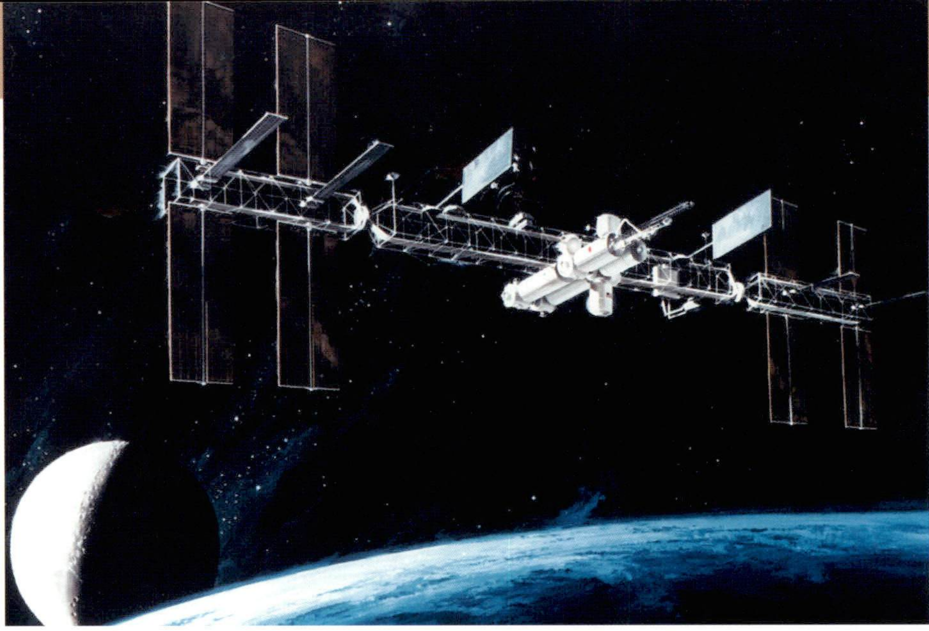


launch infrastructure and increasing reliability and responsiveness of space launch vehicles.

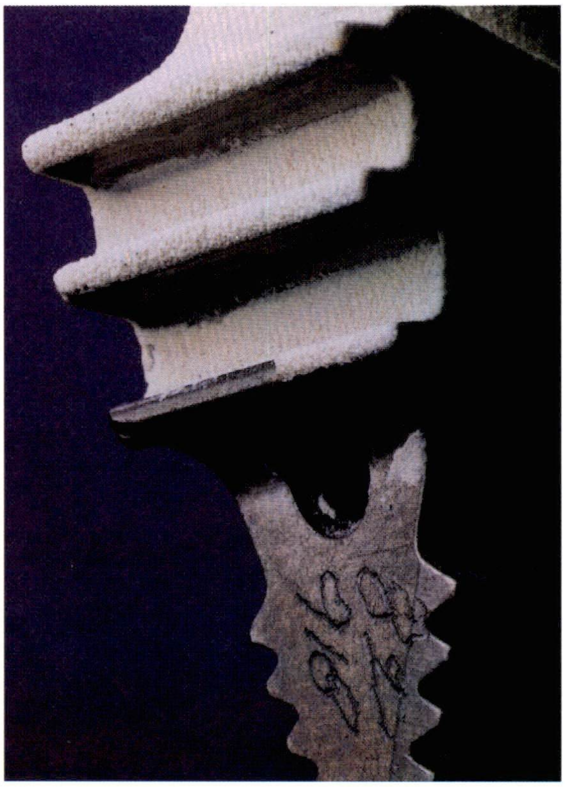
NASA is developing technology for direct commercial application in several areas. For example, the Office of Commercial Programs is sponsoring research into commercial remote sensing technology at the John C. Stennis Space Center.

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

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

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.

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

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;

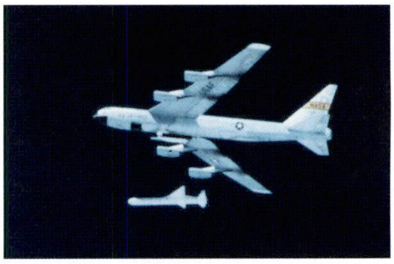
(3) to encourage the development and use of private-sector space transportation as much as possible (President Bush recently announced the National Transportation Policy which encourages the use of commercial space transportation services for government space missions to the fullest extent possible); 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.

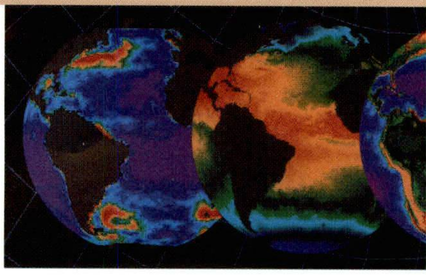
under consideration but have not yet been approved or funded, and 3) projections of commercial launch needs.
- Compare current and planned space launch capabilities with these space launch needs and identify mismatches, if any.

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

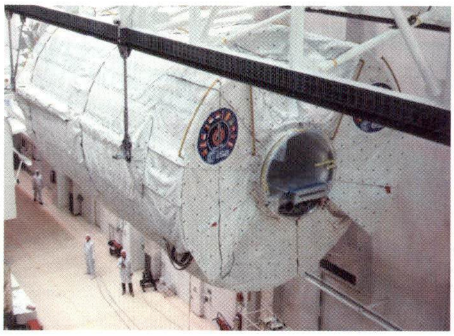
- Additional policy guidance, if needed.
- Development and acquisition of new systems or infrastructure.
- Investments in research and technology, including the government's role, if any, in development of technology for commercial application.
- Investments in advanced ("leapfrog") technologies which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

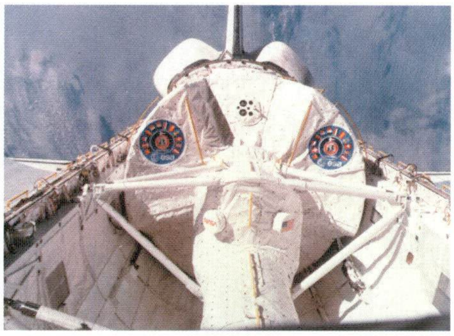
Phase 3 will assess all combinations of these policies, procedures and investments, including appropriate revisions in agency management structures or in the current assignment of space launch roles and missions. Results of the Council's analysis will be incorporated in a comprehensive space launch strategy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

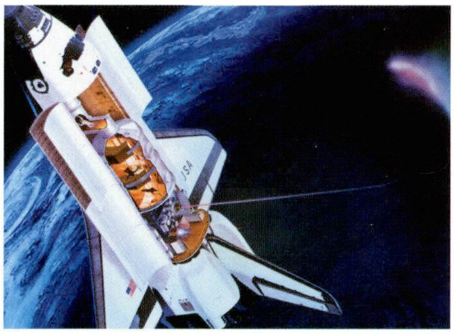
The Council explored the feasibility of international cooperation in the Space Exploration Initiative in parallel with establishment of a program policy. This interagency review examined past experience in U.S./foreign space program collaboration, capabilities of foreign spacefaring nations, the benefits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

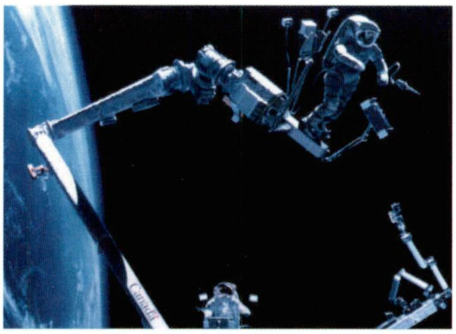
The Council concluded that the Space Exploration Initiative will be of profound significance to all mankind; and that international cooperation in this endeavor is feasible and could offer significant benefits to the United States.

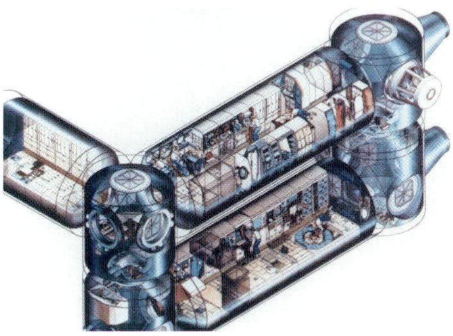
Acting on the recommendations of the Vice President and the National Space Council, the President announced on March 30, 1990, that:

- 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.

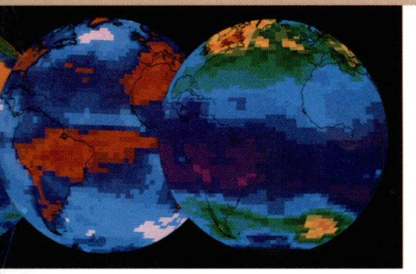
The Space Council has now convened a working group on the guidelines for exploratory dialogue.

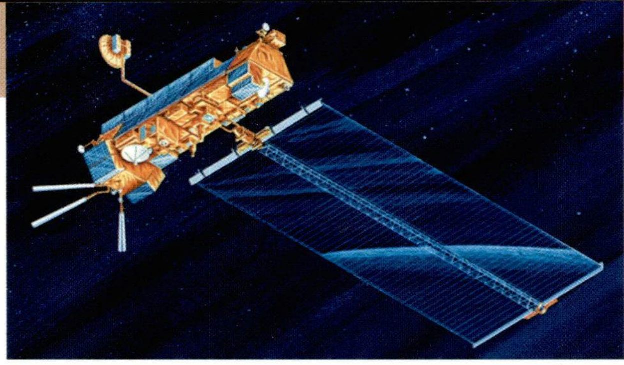






Left from top: Space lab module being serviced, Shuttle bay showing international space lab module, artist's rendition of materials processing module in shuttle bay, space station module interior, Above: Canadian robotic arm





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.

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

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.

SPACE TECHNOLOGY: BENEFITING MANKIND

Pilot (4-6) Curriculum

OCTOBER

I. Hydroponics
II. Moonsuits

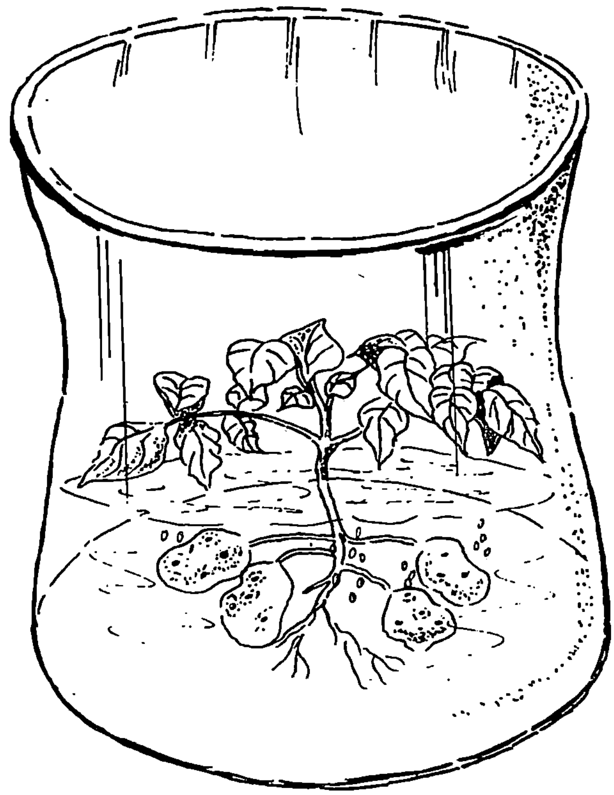
NOVEMBER

I. Space Technology
II. Optics

DECEMBER

I. Gravity
II. Growing Crystals in Space

I. HYDROPONICS...SOILLESS GROWING



INTRODUCTION

During the month of October, Pilot level Young Astronauts will learn to manipulate variables in hydroponic activities. These experiments were designed to enhance Young Astronauts' appreciation for the space technology developed to help provide residents of space stations with growing plants for nutritional and environmental needs. Preparing and analyzing data charts enable students to participate in the process of science and develop critical thinking skills.

Also this month, Young Astronauts will have fun making and consuming the results of a demonstration of the cooling process used in the development of the moonsuits that astronauts wore on the Moon. These same principles and mechanics of cooling provide hours of "normal" living for people who, because of medical conditions or occupational hazards, need to be kept physically cool.

ACTIVITY ONE

GROWING PLANTS IN WATER : INTRODUCING VARIABLES

BACKGROUND

Some researchers believe that growing vegetable plants in water (soilless) and feeding nutrients directly to the plant's root allow for a more healthy plant, since the root does not have to search for nutrients and water.

SAFETY

Nutrients should be handled by the teacher. Children should be cautioned about washing hands and keeping the nutrient away from the face.

OBJECTIVES

Young Astronauts will---

1. Observe vegetable plants growing in water.
2. Observe vegetable plants growing in soil.
3. Compare hydroponically-grown plants to those grown in soil.
4. Define and demonstrate the use of variables.
5. Graph the rate of growth.
6. Investigate the effects of adding a vegetable plant nutrient to the vegetable plant growing in water.
7. Draw conclusions based on the experiments.

PROBLEM

How do hydroponically-grown plants compare with plants grown in soil?

MATERIALS

root vegetable plant (sweet potato)
stem vegetable plant (potato)
bulb vegetable plant (onion)
plant nutrient
water
containers of choice (paper cups, pots, milk cartons, etc.)

PROCEDURE

1. For root vegetable: (sweet potato)
   a) Put a firm small sweet potato in a jar of water with pointed end down.
   b) Add enough water to cover half the sweet potato.
   c) Stick toothpicks in potatoes and rest them on jar.
   d) Put jar in warm, dark place.
   e) When tiny roots and stems appear, place jar in sunlight.

2. For stem vegetables: (potato)
   a) Use small potato or cut large potato in sections. Each section must have an "eye".
   b) Place potato with "eye" up in sandwich bag.
   c) Add 2 cm of water.
   d) Tape or tack bag on board.

3. For bulb vegetables: (onion)
   a) Place the onion bulb in sandwich bag with root section in bottom of bag.
   b) Add 1 cm water to bag.
   c) Tape or tack bag to board.

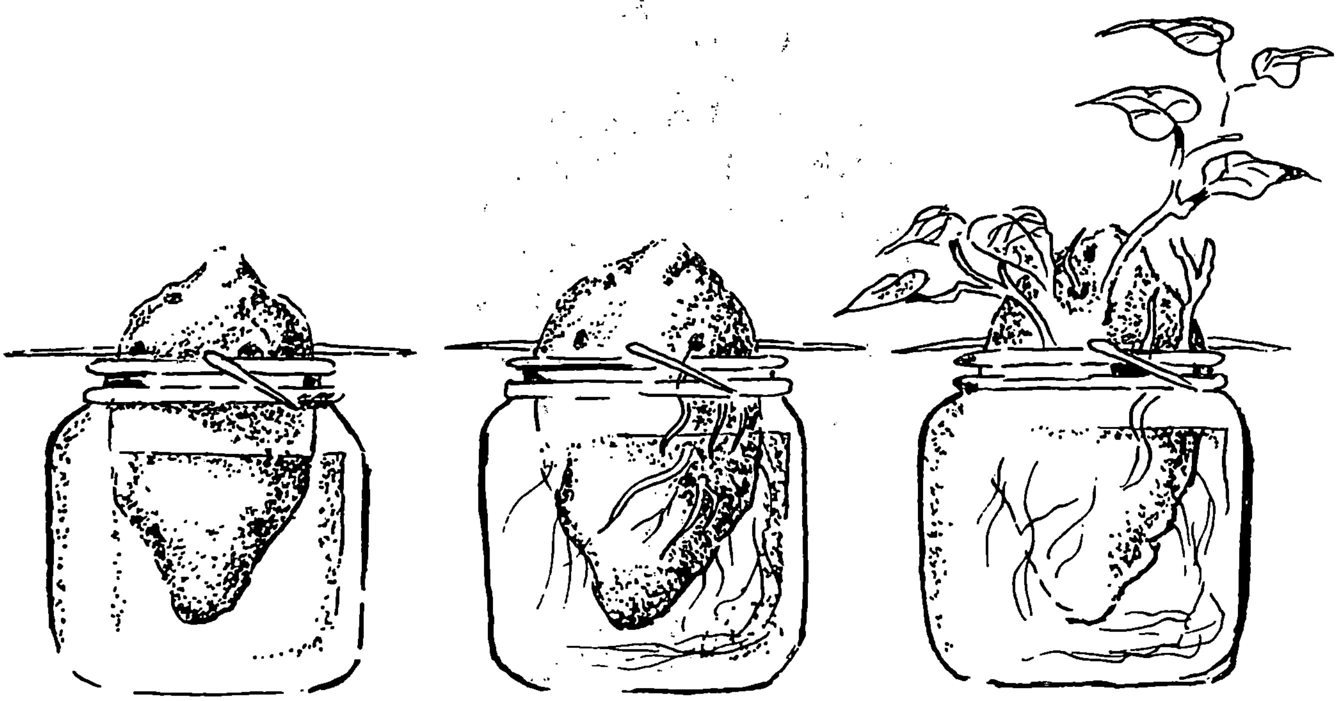
4. Add nutrients to one group of plants in water.

5. Plant one group in soil, after rooting in water.

6 Allow third group of vegetable plants to remain in water only.

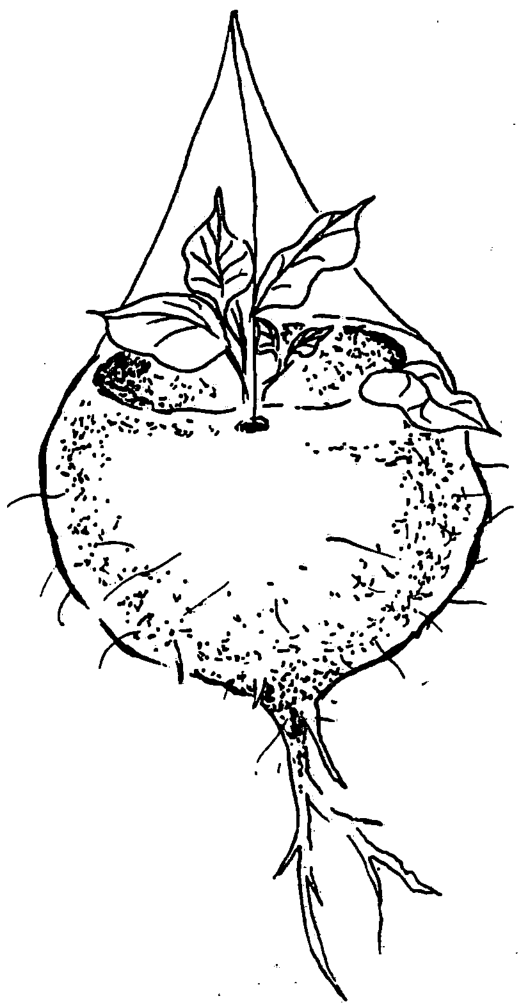
EVALUATION

1. Compare and record the growth patterns.
2. Construct a graph showing the effect of each variable upon the growth pattern.
3. Which of the three experiments produced the healthiest plant?



EXTENDED ACTIVITIES

1. Investigate other variables: temperature, artificial light, different soil mixes and/or water mixes.
2. Grow a root vegetable "hanging garden" from turnips, beets or any other root vegetable plant.
    a. Select a nice fat beet.
    b. Cut off the leaves and stems.
    c. Hollow the beet out from the pointed end.
    d. Push 1/2 of a toothpick into 3 sides of the beet, but not all the way in.
    e. Tie heavy thread to each toothpick end and knot the strings together at the top.
    f. Hang the beet on a hook or nail--- it will become its own hanging basket.
    g. Keep the hollowed-out section filled with water.



ACTIVITY TWO

GERMINATING SEEDS IN WATER

BACKGROUND

This activity enables students to observe in detail the germination of seeds and to note the differences in germination of "monocot" and "dicot" seeds under various environmental conditions.

OBJECTIVES

Young Astronauts will---

1. Observe in detail the structure of seeds.
2. Name and identify monocot and dicot seeds.
3. Determine environmental conditions under which monocot and dicot seeds germinate best.
4. Record and communicate findings through graphing, drawings and/or oral reports.

PROBLEM

Does the structure of a seed determine its sprouting time?

MATERIALS

lima beans (dicot)
corn seeds (monocot)
growing medium-water
microscopes

Zip loc bags/plastic containers
paper towels
metric measurement tools

magnifying glasses

PROCEDURE (Pairs or Teams)

(1) Soak several lima beans and corn seeds overnight--- before observing. (2) Observe external structures and make drawings. (3) Carefully open and observe internal structure--- make drawings. (4) Place remaining whole seeds into selected container and add water. (5) Observe sprouting, record, measure. (6) Vary temperature, moisture, oxygen.

EVALUATION

1. Which seed sprouted first? (germination time)
2. Which seed grew faster?
3. Analyze your drawings to determine results.

EXTENDED ACTIVITIES

Plan a vegetable garden.

1. (Beans and Corn). Based on the results of your findings, which vegetable would you plant first in order to have the highest yield? Why?
2. If nights were much longer than days, which vegetable plant (bean or corn) would you plant first in order to receive the highest yield? Why?
3. Explain "winter wheat".

ACTIVITY THREE

GROWING VEGETABLE PLANTS HYDROPONICALLY FROM SEEDS

BACKGROUND

Current research involves growing plants from seeds in a special space-like environment. Wheat and soybeans have been grown hydroponically in this environment--- where scientists monitor a number of conditions.

OBJECTIVES

Young Astronauts will---

1. Measure the height and weight of selected seedlings grown under different conditions and in different environments.
2. Predict the average height and weight of selected seedlings grown with and without a nutrient, sunlight vs artificial light, light vs darkness.
3. Draw conclusions about the requirements for growing healthy selected seedlings based on selected data.
4. Communicate the results through writing, speaking, consulting charts and graphs.

PROBLEM

What are the best conditions for growing selected seedlings hydroponically?

MATERIALS

mung beans
oats
barley
lima beans
corn
paper towels
plastic sandwich bags
nutrient
grow light
germinator (if possible)
metric measurement tools

SAFETY

Students should wash their hands after handing nutrients and seedlings. Hands are to be kept away from the face.

PROCEDURE

(1) Fold a paper towel and place it in the ziploc bag. (2) Plant at least five of your selected seeds in the bag. (3) Add six to eight teaspoons of water. (4) Fold the bag. (5) With a paper clip, attach a small piece of paper. Write the date, the name of the seed, and how much water. (Add water when

needed). (6) Decide the variable or combination of variables you wish to use: light or dark; nutrient or plain water, etc. You may need more than one bag and more than one set of seeds. (7) Record all data giving dates, etc, using chart below as guide.

EVALUATION

Each group (singles, pairs or groups) will carry out evaluations based on their selected seeds and variables.

1. What conditions produced negative results?
2. What conditions produced positive results?

EXTENDED ACTIVITIES

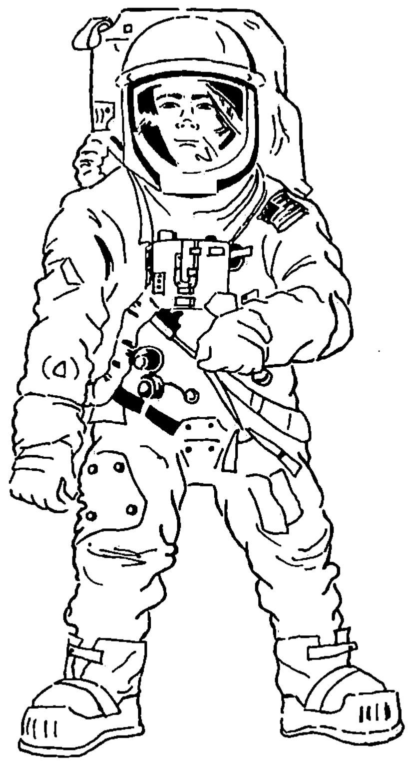
1. You are given a module in which to grow vegetables hydroponically. Which vegetables, and under what conditions would you plant seeds in order to reap the highest yield?

HEIGHT OF SEEDS GROWN IN WATER (in millimenters)

	Day 2	Day 4	Day 6	Day 8	Day 10
Seed 1					
Seed 2					
Seed 3					
Seed 4					
Seed 5					
Seed 6					
Seed 7					
Seed 8					
Seed 9					
Seed 10					
Average Height					

Seeds Grown in plant minerals & water	Growth in millimeters
Average seed growth by Day 2	
Average seed growth Day 2 to Day 4	
Average seed growth Day 4 to Day 6	
Average seed growth Day 6 to 8	
Average seed growth from Day 8 to 10	

II. MOONSUITS: A Cool Idea



BACKGROUND INFORMATION

Astronauts who walked on the Moon had to wear special clothing to protect their bodies. NASA scientists developed spacesuit underwear that lowered body temperatures by circulating a cooled fluid through a system of tubes.

In 1987, nearly 20 years later, that technology was used to save a young boy's life. Born without sweat glands that allow excess heat to escape from our bodies, the boy's activities were severely restricted. Any activity or environment that caused his temperature to rise was life threatening.

The boy was given a cool suit patterned after the NASA space underwear. The suit contained a system whereby cooled fluid was circulated by a battery-powered pump through a series of tubes in a head cap and wraparound torso vest. The suit reduced the boy's body heat by 50 percent and lowered his heart rate to an acceptable level.

Others have benefited from different versions of the cooling suit. They are used by people in occupations that can raise body temperaturess to dangerous levels and threaten heat exhaustion, stroke or even death.

ACTIVITY

"CHILL-OUT" : ICE CREAM IN A BAG

BACKGROUND

The amount of heat present in any body or environment is an important factor. Many chemical and physical reactions will only occur at certain temperatures. In some cases, too much heat can be dangerous. The ability to cool a material can be very important and can have a variety of effects.

OBJECTIVE

The Young Astronauts will explore and observe the effects of cold (cooling) on milk.

PROBLEM

How will cooling affect milk?

MATERIALS

1 cup measure	milk	ice
1 tablespoon and 1 teaspoon	sugar	salt
measuring spoons	vanilla	cups
gallon freezer bag		
pint freezer bag		

PROCEDURE

1. In a pint freezer bag, mix the following:
   1 cup milk
   4 tablespoons sugar
   1 teaspoon vanilla
   Seal the bag.
2. In the gallon bag, mix the following:
   2 cups ice
   3 tablespoons salt
   the pint bag (sealed)
   Seal the bag.
3. Mix for 15 minutes. Gently shake the gallon bag so that the smaller bag moves around in the ice and salt mixture.
4. Observe the contents of the smaller bag. Describe what is happening.
5. Taste the results.

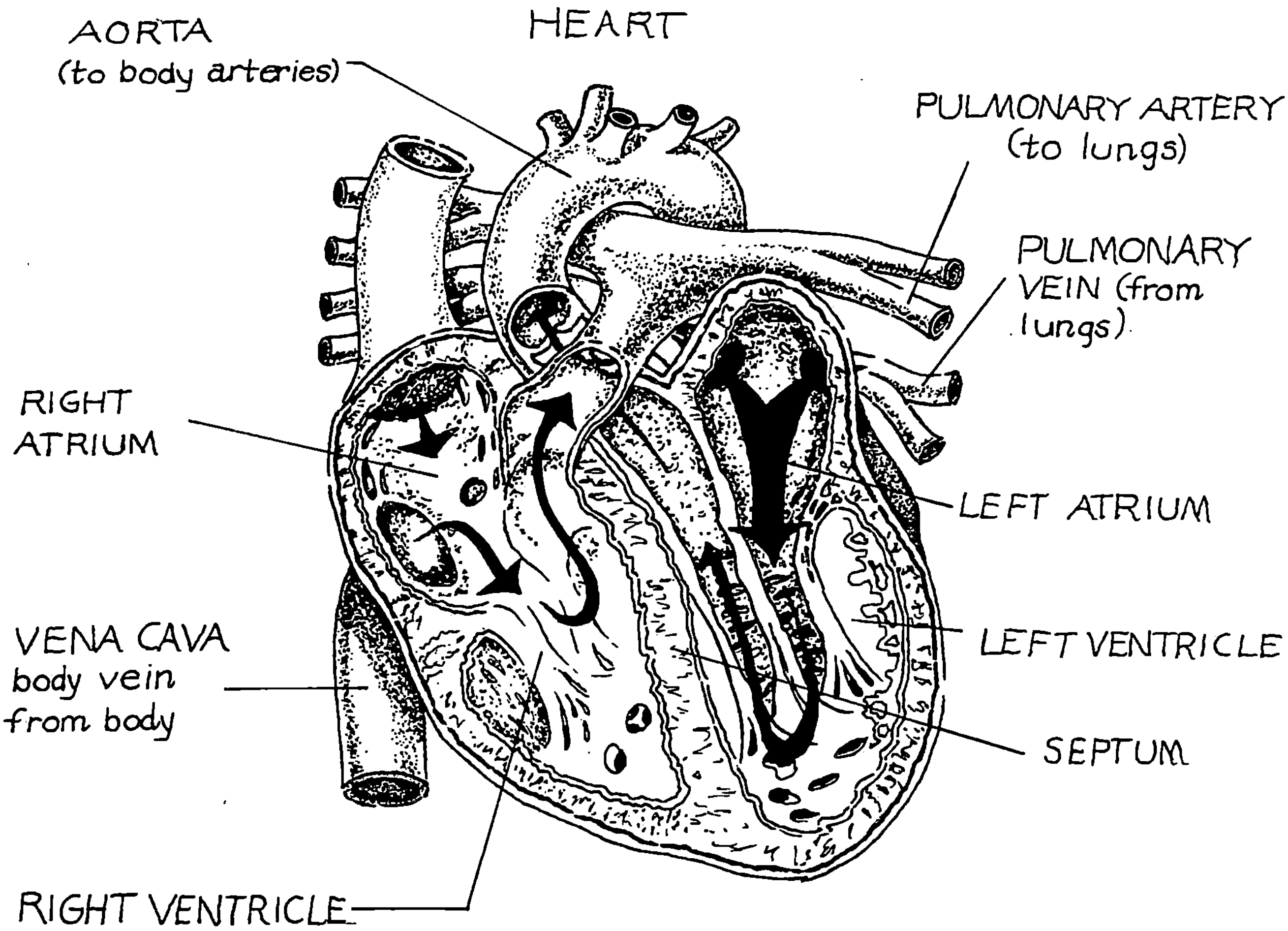
EVALUATION

1. Discuss what happened.
   Why did it happen? How did it happen?

EXTENDED ACTIVITIES

1. Try this activity with other liquids.
2. Measure and record the temperature of the milk mixture at different times during the experiment.

I. SPACE TECHNOLOGY : Heart Monitoring

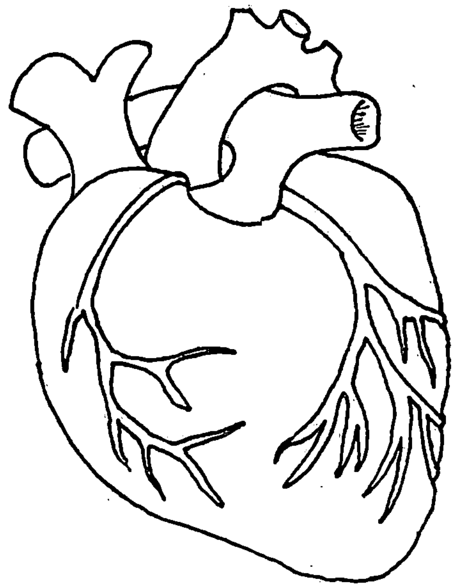


INTRODUCTION

In November, Pilots will learn about the human heart, its structure and its healthy functioning. Young Astronauts will explore the effects of space travel on the human heart.

Also this month, Pilots will explore the fascinating world of optics. The study of light plays a key role in the scientific work astronauts perform in space. Lasers help map distances on Earth as well as in space. Space technology developed in the field of optics has enabled us to "see" the physical universe much better. Treatments and medical procedures developed as a result of analyses of experiments done in space have revolutionized the approach to vision problems.

The Heart



BACKGROUND INFORMATION

Space travel is hazardous to the well-being of astronauts. One problem associated with prolonged space travel is the effect of weightlessness on the human body, especially the heart.

Weightlessness causes the blood and other bodily fluids to move to the upper body. This causes the heart to enlarge to handle the increased blood flow.

Muscles, including the heart, are particularly vulnerable to deterioration on long space flights. Any weakening of the heart threatens the functioning of the entire cardiovascular system, which can affect every organ in the body.

NASA scientists developed a complicated monitoring system for astronauts that communicated the performances of body systems and organs under weightlessness. This technology was used in the design of a broad line of computerized medical electronic systems which helped revolutionize medical care. Some examples are the pacemaker, which regulates the heartbeat through electrical stimulation; heart rate monitors; systems that allow doctors and nurses to monitor a patient's vital signs from a distance; and angioplasty, a non-surgical procedure for unclogging the arteries.

A communications system developed by NASA for space communication between Earth stations and satellites also had important implications for medical treatment. It led to the development of an advanced pacemaker that can be regulated to meet the patient's physical needs. The implanted device has two parts that work together to coordinate the beating of the heart's chambers, allowing the patient to lead a normal life of physical activities.

ACTIVITY ONE

BACKGROUND

The heart is an organ that works like a pump. It keeps blood moving through the circulatory system. Your heart is about the size of your fist. To help you imagine the size and location of your heart, make a fist with your left hand and place it slightly left of the center of your chest.

Your heart is divided into two upper and two lower chambers. The two upper chambers of the heart are called atria (AY tree uh). Each one is called an atrium. The lower chambers are called ventricles. The right and left sides of the heart are divided by a thick wall called the septum. You have an atrium and a ventricle on the left side of your heart and an atrium and a ventricle on the right side. Your septum is in the middle.

Blood enters the heart from the body through a large vein called the Vena Cava. It first goes to the right atrium and then passes through a heart valve into the right ventricle. From the right ventricle, blood travels through the pulmonary arteries into the lungs to receive oxygen. The blood returns to the heart through the pulmonary veins to the left atrium and then goes through a heart valve to the left ventricle. This ventricle is the strongest part of the heart. It pumps the blood into the aorta, the main artery of the body. The aorta carries the blood to the rest of the arteries of the body. Find the atria, ventricles, septum and aorta in the drawing of the heart.

Your heart is made of cardiac muscles and other tissues. When the cardiac muscles of your atria and ventricles contract, blood is forced throughout the blood vessels of your body. Your blood transports food and wastes to and from your body cells.

OBJECTIVES

Young Astronauts will---

1. Describe the heart and its function.
2. Make a model of the heart and identify by color code and/or flag the aorta, the atria, ventricles and septum.

MATERIALS

clay, Play Doh, or silly putty	newspapers
	toothpicks

PROCEDURE

(1) Mold the clay into a model of the heart. (2) Color code and flag the aorta, atria, ventricles and septum.

EVALUATION

Use your clay model to name and identify the divisions of the heart.

EXTENDED ACTIVITIES

1. Explain the function of the heart.
2. Name ways to keep your heart healthy.

ACTIVITY TWO

NATURE OF MUSCLE TISSUE

BACKGROUND

Muscles are made up of fibrous tissue bound tightly together. This muscle tissue is made up of cells which can contract. Some muscles are voluntary, some muscles are involuntary. Voluntary muscles move when you tell them to move. Involuntary muscles can move without conscious thought. But sometimes a voluntary muscle becomes an involuntary muscle.

OBJECTIVE

Young Astronauts will---

1. Demonstrate the use of voluntary muscles.
2. Describe when voluntary muscles become involuntary muscles (shivering is an example).
3. Explain how we develop strong, healthy muscles.
4. Describe and diagram muscle fiber.

MATERIALS

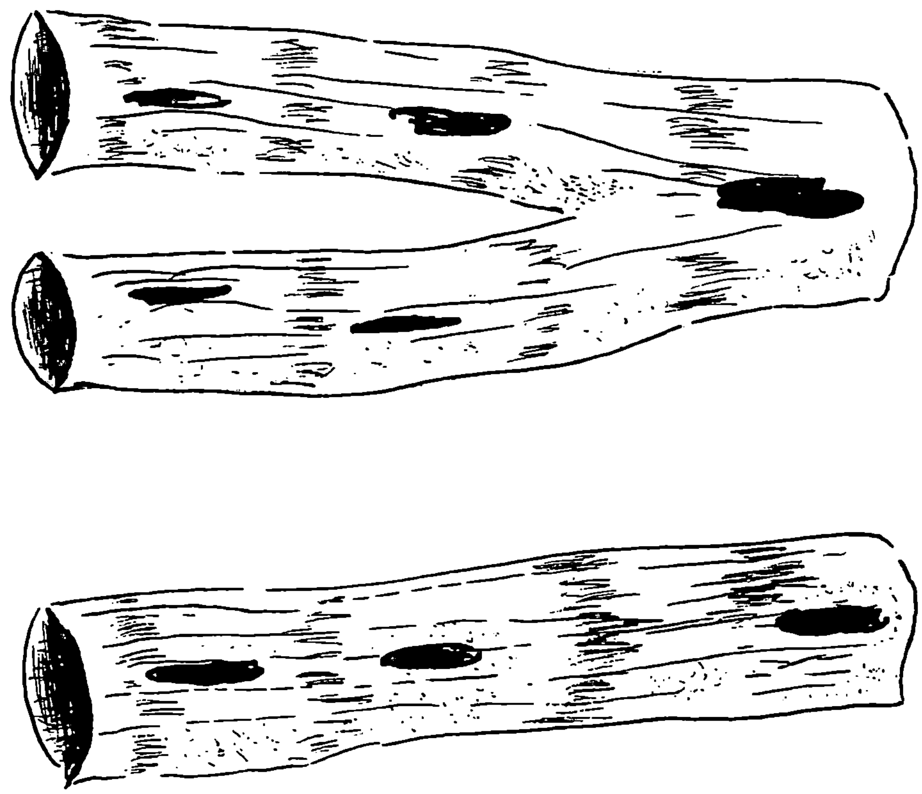
straight pins
small piece of beef
paper towels
magnifying glasses
microscopes

PROCEDURE

(1) Place the paper towel on a table or a desk. (2) Put a small piece of beef on the paper towel. (3) Use the straight pin to pick and separate the long thin strands that are fibers of muscle tissue. (4) Place a small, thin piece of muscle fiber on a slide under a coverglass. (5) Draw what you see under the microscope. Does it look like the following diagram?

EVALUATION

1. Diagram the muscle cells.
2. What makes muscles expand and contract?



HEART MUSCLE TISSUE FIBERS

EXTENDED ACTIVITIES

1. Describe other ways in which voluntary muscles become involuntary muscles.
2. Make a working model of a muscle.

ACTIVITY THREE

MICROGRAVITY AND HEART FUNCTIONS

BACKGROUND

In a microgravity environment, muscles and blood vessels lose their strength. There is a loss of muscle tone and muscle nitrogen. Since the heart is a muscle, the effects of weightlessness on muscles is an especially serious problem.

To overcome muscle deterioration, astronauts must exercise regularly.

OBJECTIVES

Young Astronauts will demonstrate the effects of muscle tone loss.

PROBLEM

What is muscle tone?

PROCEDURE

(1) Bunch and tie several red rubber bands together, roughly in the shape of a heart. (2) Each day stretch your heart model in each direction for 5 minutes. (3) Each day, record the measurement of the model before stretching and after, as well as the length of the stretch.

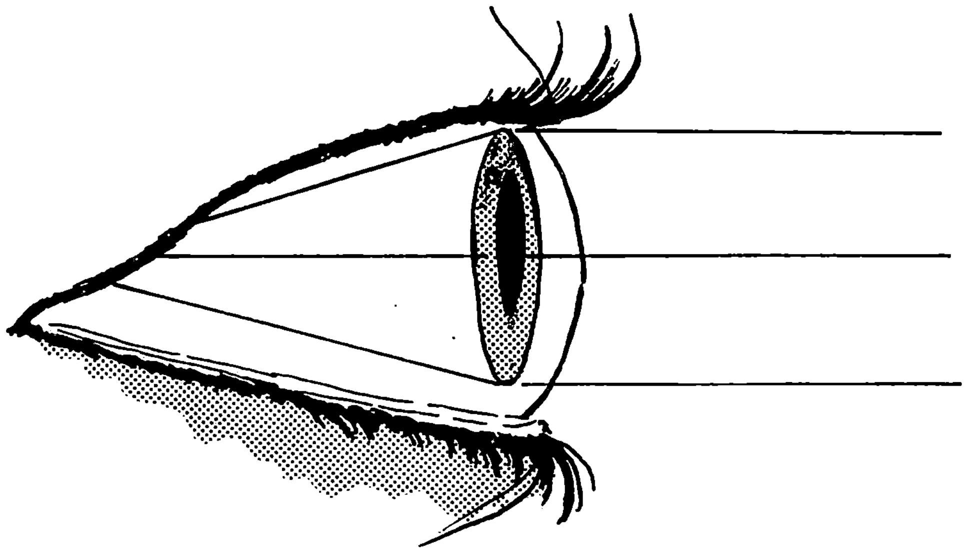
EVALUATION

1. What happened to your heart model?
2. What happened to the muscle tone?

EXTENDED ACTIVITY

Think of other ways to demonstrate muscle tone loss.

II. OPTICS : USING LIGHT



BACKGROUND INFORMATION

Our Sun provides the Earth with energy in the form of light and heat. The total array of energy waves is called the electromagnetic spectrum. The part of the spectrum which we can see as light is the visible spectrum from red to violet. The invisible part beyond the red is called the infrared and is felt as heat. The Sun's radiation is so powerful that its radiation could hurt us if the Earth's atmosphere didn't block out most of the harmful rays.

When light waves are bent, they separate into the colors the spectrum. This is called refraction. In nature, we see refraction taking place when we see a rainbow.

Much of the space-based research and many of the resulting developments, including those with practical uses here on Earth, have centered on light. One of the most amazing discoveries from this research is the laser, a device that amplifies the radiation of visible light frequencies, allowing them to travel in a narrow beam in one direction and on the same wavelength.

Laser technology based on NASA research has resulted in safer, non-surgical procedures for treating disease, more accurate measurements of long distance points and improvements in eye surgery. For example, at one time the removal of cataracts in the eye required surgery and a lengthy hospital stay. Today, most cataracts are removed by laser treatment on an out-patient basis and the person can go home in several hours.

NASA research led to greater understanding of how the eye works and of how a person can control eye movement. This knowledge is being used to develop techniques that help improve common vision problems such as nearsightedness and farsightedness.

ACTIVITY ONE

OPTICS : THE SUN'S SPECTRUM

BACKGROUND

The light we see from the Sun is called white light. White light is made up of different colors (red, orange, yellow, green, blue, indigo and violet) which we can readily see through an object called a prism. A prism "breaks up" the colors so that we see a layered band of colored stripes. This is called the visible spectrum, a small part of the electromagnetic spectrum. The colors of the spectrum are arranged in order of wavelengths from red to violet. On the red end of the visible spectrum is invisible light or infrared and on the blue end of the spectrum the invisible light is ultraviolet.

OBJECTIVES

Young Astronauts will---

1. Identify and order the colors of a spectrum.
2. Describe color intensity.
3. Describe white light.

PROBLEM

What colors make up white light?

MATERIALS

prism or glass of clear water and mirror	white sheet of paper
crayons or colored markers	light source

PROCEDURE

(1) Hold a prism up to the light source so that the light shines into the paper through two sides of its triangular surfaces. (2) Turn the prism at different angles until a spectrum (rainbow colors) appears on the white paper. (3) Observe the colors of the spectrum. (4) Draw and color the spectrum.

NOTE: If prisms are not available, place a mirror in a glass of clear water, lean the mirror to one side. Place the glass in the light. Hold the white paper so that the light reflects from the mirror onto the paper (keep the paper very still).

EVALUATION

1. What are the colors of a spectrum? Name the colors in order.
2. What does Roy G. Biv stand for?

EXTENDED ACTIVITY

Construct a color wheel.

ACTIVITY TWO

HOLOGRAMS : OPTICAL IMAGES

BACKGROUND

Holography is a lensless photographic method that uses laser light to produce three-dimensional images. By the use of coherent light waves (waves that are of the same phase), images are usually formed on a photographic plate. These images do not usually bear any resemblance to the original object and therefore must be reconstucted by illuminating them with coherent light. The resulting image is called a hologram.

OBJECTIVES

Young Astronauts will---

1. Describe the images and colors that are produced.
2. Name colors that were reflected.
3. Name colors of the spectrum that were equally reflected.
4. Describe the holograms when seen at different angles.

SUGGESTIONS FOR FINDING HOLOGRAMS

Art supply stores/catalogs, optical supply stores, photographic supply catalogs, science equipment catalogs, sports cards.

MATERIALS

strong flashights
white light holograms

PROCEDURE (work in pairs)

(1) Hold the hologram in front of the flashlight. (2) Slowly tilt the hologram back and forth, left and right. (3) Tilt the holograms. Record the colors of the spectrum seen at different angles.

EXTENDED ACTIVITIES

1. Substitute color filters or filter paper for the hologram.
2. Collect and make a list of holograms that you can find on books, cereal boxes, credit cards, etc.

ACTIVITY THREE

MEASURING DISTANCES: YOUR WALK MINUTE

BACKGROUND

Over twenty years ago, the Apollo astronauts left a reflecting target on the Moon. Scientists on Earth aimed a large beam at the reflector. By measuring the time it took the beam to travel back to Earth, scientists were able to calculate time, distance and speed, which enabled them to figure out, with greater accuracy, the distance between the Earth and the Moon.

Today NASA scientists use the laser, which is directed through telescopes, not only to get accurate measurements of the distance between the Earth and Moon, but also to measure with great accuracy the movement of the Earth's continental plates and to track the speed of satellites in orbit.

OBJECTIVE

Young Astronauts will measure walking over a specific period of time.

PROBLEM

What is your average walking speed?

MATERIALS

stopwatch
string
measuring tape or meter stick
marker (baseball bases)

PROCEDURE

Form groups of four and assign to each group member the task of walker, time keeper, measurer and recorder.

(1) Choose a place to walk and measure your walking speed. (2) Map out your walking course (playground, athletic field). (3) Walk for one minute. Measure the distance you walked. Record the distance. (4) Repeat step 3 twice. (5) Make two additional one-minute walks on the same walking course. Measure and record the distance each time. (6) You should now have three recorded distances that you have walked along the same course. (7) Add the three distances. Divide the sum of the distances by three. This will give you the average. This is your walk-minute. Ex: Tim walked 40m, 45m and 45m. The total is 130m. Divide by 3. The average walk is 43m. (8) Now find the averages for others.

EVALUATION

1. What was your average walking speed in a minute?
2. What was the fastest average walking speed in your group?
3. What was the lowest average walking speed in your group?

EXTENDED ACTIVITY

Find the average walking speed of the entire class. Graph your results.

LASERS : EYE SAFETY

BACKGROUND

There are different classes of lasers. Low power lasers, like those used in supermarket checkout line scanners, are harmless and cause no health problems. More powerful lasers can cause eye and other bodily damage. It is important never to look directly into the laser beam or its reflection.

Scientists have developed safety lenses that protect the eyes against certain types of laser light. People who work with strong, intense light can develop blind spots if they do not wear protective lenses.

OBJECTIVE

Young Astronauts will locate blind spots in their eyes.

PROBLEM

Where are your blind spots?

SUGGESTION

How should one measure this distance?

MATERIALS

white plain index cards
pencil or black marker

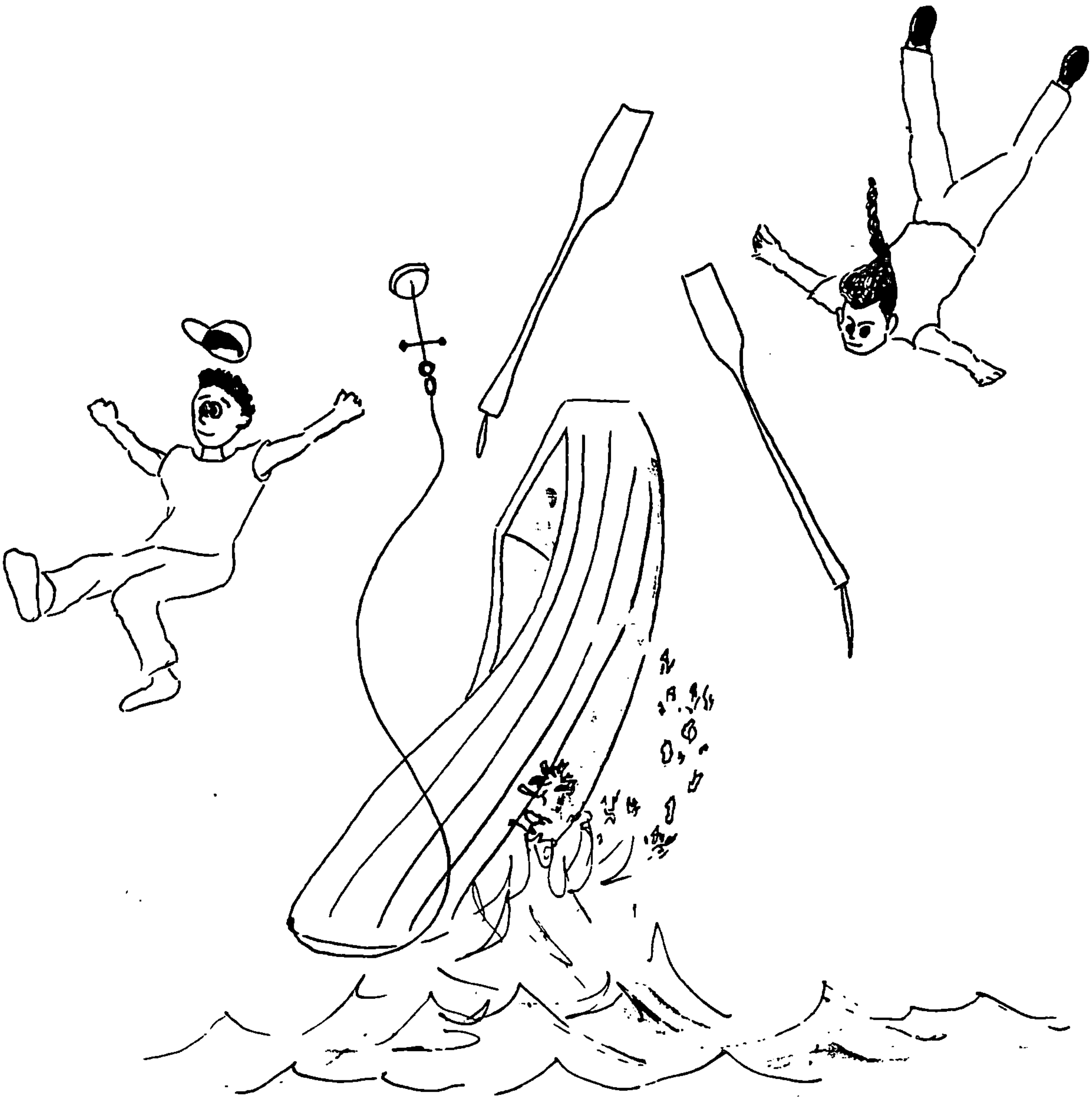
PROCEDURE (work with a partner)

1. Place two black dots on your card about 7 centimeters apart.
2. Hold the card in your right hand. Close your left eye and stare at the left dot with your right eye. Move the card out to arm's length and slowly bring the paper toward your right eye.
3. When the dot on the right disappears, have your partner measure the distance from your eye to the card. Record your distance. This is your blind spot.
4. Repeat the steps 2 and 3 with your right eye closed. Now let your partner try it.

EVALUATION

1. What is the blind spot distance in your left and right eye?
2. Are the distances the same or different?

I. GRAVITY



INTRODUCTION

In December, Pilots will involve themselves in the push and pull of Earth forces, first by investigating measurements of gravity and mass, and second by observing the formation of crystals. The gravitational differences between space environments and Earth environments have allowed scientists to design shuttle experiments that produce large, pure and perfect crystals. These crystals have many applications in electronics, industry and science on Earth.

BACKGROUND INFORMATION

Gravity is one of the most common forces recognized by man. Gravity is the pull the Earth exerts on all matter within its field of influence. This area is known as Earth's gravitational field. The farther one moves from the Earth, the weaker the force becomes.

Spacecraft and astronauts orbiting the Earth are in an environment of microgravity. The force of gravity that pulls the spacecraft toward Earth is matched by the craft's forward speed. This causes them to "fall freely" in space.

The advent of the space shuttle opened a new era in microgravity science and applications. Scientists were able to study the effects of microgravity on the human body and its functions. The result has been the development of new techniques in areas such as cardiology which have benefited thousands of people.

Research in crystal growth also has been pushed forward by developments in space exploration. Astronauts have been able to grow large, pure and nearly perfect crystals in shuttle experiments. Such crystals are needed in sophisticated industrial and electronic devices.

Microgravity space experiments also are yielding information that will have important implications for fields such as optics, electronics and chemical processing.

ACTIVITY ONE

MEASURING FORCES

BACKGROUND INFORMATION

A force is any push or pull on an object. Weight is the amount of force (pull) the Earth exerts on an object. We call this force gravity, and it is a property of all matter. The Earth exerts a force of gravity on every object on or near its surface. The larger the object the greater the force of gravity.

A spring scale can be used to measure the force of gravity or find the weight of something. This measurement is expressed in units called "newtons (N)."

Weight and mass are different. Weight is a force and mass is the amount of matter (stuff) in an object. For example, the mass of a one kg. bag of potatoes is one kg. The weight of the one kg. of potatoes is 9.8 N. A D-size battery has a mass of about 102 g. It weighs about 1 N.

OBJECTIVE

Young Astronauts will demonstrate the ability to measure the effect of gravity.

PROBLEM

How can you measure the force of gravity?

MATERIALS

spring scale
rope string or cord
wood block

PROCEDURE

(1) Obtain a spring scale and a one-meter length of string. (2) Tie one end of the cord around the object. (3) Tie a small loop in the other end of the string. Attach the spring scale to the loop. (4) Drag the object across your desk top. Note and record the readings on your spring scale when the object starts to move and after it is moving. (5) Using the spring scale, lift the object off the desk. Again note and record the reading on the scale in a table. Compare the amount of force needed to start, drag and lift the object.

EVALUATION

1. Make a list of forces.
2. Which force do you think is largest? Smallest?
3. Define the terms **newton** and **force.**

ACTIVITY TWO

MASS AND WEIGHT

OBJECTIVE

Young Astronauts will discover the difference between mass and weight.

PROBLEM

How is weight different from mass?

MATERIALS

5 different objects (such as book, shoe, eraser, wooden block, etc.)
string
balance/scale

PROCEDURE

(1) Estimate the weight of each of the chosen five objects in newtons and record it in your notebook. (2) Obtain a spring scale and a long piece of string. (3) Weigh each object and record the weight. (4) Repeat Procedures 1-3 using balance/scale. (5) Compare the measurements.

EVALUATION

1. Which object weighs the most?
2. Which object weighs the least?
3. How is weight different from mass?
4. How can an object be weightless but not massless?

ACTIVITY THREE

FALLING OBJECTS

BACKGROUND

Falling is caused by gravity. Near the Earth a falling object falls (accelerates) at a rate of $9.8 m/s^2$ (meters per second squared). That means that the speed of the falling object increases by 9.8 meters each second. This value is called the acceleration of gravity. All objects falling near the Earth fall at the same rate when there is no air or other matter to slow the fall of the object.

OBJECTIVE

Young Astronauts will graph and interpret data on gravity.

PROBLEM

What is the acceleration (increasing speed) of a falling object?

TABLE ONE

Time of Falls (s)	Speed (m/s)
1	9.8
2	19.6
3	29.4
4	39.2
5	49.0
6	58.8

MATERIALS

graph paper
pencil
ruler

PROCEDURE

(1) On a sheet of graph paper make a graph using the data given in table 1. Label the time on the horizontal axis from 1-10 seconds. (2) Label the speed on the vertical axis from 0-100 m/s. (3) Plot the speed for each second of time as given in the table. (4) Draw a line to connect the points you have plotted.

EVALUATION

1. How could you use your graph to find the speed at 8 seconds?
2. What is the speed at 9 seconds? 10 seconds?

EXTENDED ACTIVITIES

(1) The more massive the object, the greater the force of gravity, so the force of gravity on the Moon is less than Earth's gravity. Explain how the speed of falling objects is different on the Moon.

(2) The force of gravity on the Moon is one-sixth of that of Earth. How high would you jump on the Moon if you could jump 4 feet on the Earth?

II. GROWING CRYSTALS IN SPACE

BACKGROUND INFORMATION

Most minerals are formed as crystals. Crystals of different minerals have different shapes. The crystal shape (geometric pattern) is always the same for a given mineral, although the crystals may vary in size.

The study of crystals is of great importance to the field of metallurgy, since the properties of metal alloys frequently depend upon the structure of the component elements.

Astronauts grew crystals aboard Spacelab and the shuttle. Crystals grown in space are very pure and nearly perfect because they do not have to combat Earth's stronger force of gravity. These crystals can be used to make new forms of metals that are very light and very strong. Pure, nearly perfect crystals are required in computers, lasers and numerous other optical and electronic devices. Growing crystals in space permits a purity and uniformity that cannot be equaled on Earth.

The development of liquid crystals--- a form of matter between liquids and solids--- represents another space technology application. The color change characteristic of liquid crystals has produced temperature indicators, digital thermometers, disease diagnosis, hot/cold indicators and other devices.

ACTIVITY ONE

GROWING CRYSTALS: COOLING QUICKLY, COOLING SLOWLY

BACKGROUND

Most minerals are formed as crystals. Crystals of different minerals have different shapes. The crystal shape (geometric pattern) is always the same for a given mineral, although the crystals may vary in size.

OBJECTIVE

Young Astronauts will observe the effects of rate of cooling on the formation of crystals.

PROBLEM

How does the rate of cooling affect the formation of crystals?

MATERIALS

string
teaspoon
bolts, nails or paper clips
hot plate (or heat source)
water
2-2/3 cup sugar or salt
pyrex beakers
pencils

SAFETY

Adult Supervision Required.

PROCEDURE

(1) Put 1/4 cup of water in each of the pyrex beakers. (2) Heat beakers of water on hot plate until the water boils (Caution : **Glass will break. Pyrex will not break).** (3) Add 2/3 cup of sugar slowly to each beaker of boiling water, stirring as sugar is added---until all the sugar is dissolved. (4) Turn off hot plate. (5) Tie a bolt, paper clip or nail on to one end of the string. (6) Wrap or tie the other end of the string around a pencil. (7) Suspend the bolt, paper clips or nail in the sugar solution by resting the pencil across the top of the beaker. (8) Repeat with other beaker. (9) Place one beaker on a window sill (or other location where it will not be disturbed). (10) Place other beaker in a cold place (refrigerator, ice chest). Do not disturb. Do not touch solution.

EVALUATION

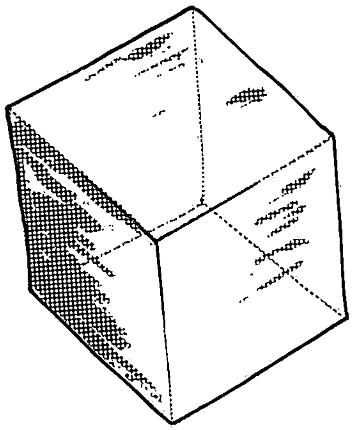
1. Observe and compare crystals growing in two different locations.
2. Where do the crystals grow first? How do the crystals grow?
3. What are the differences between crystals formed in slowly cooling solutions and solutions cooling rapidly?

EXTENDED ACTIVITY

Repeat the same experiment with salt.

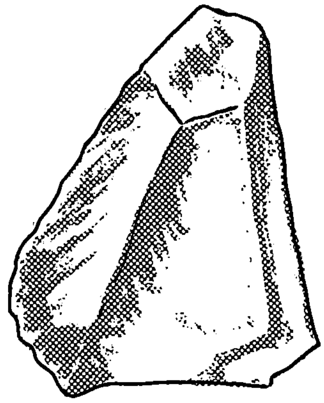
THE SIX BASIC CRYSTALLINE SHAPES

HALITE (salt)



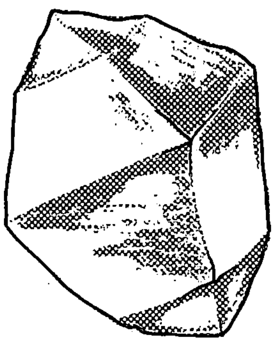
Cubic System

CALCITE



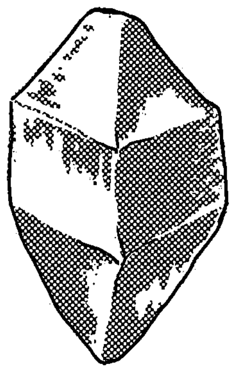
Hexagonal System

SULPHUR



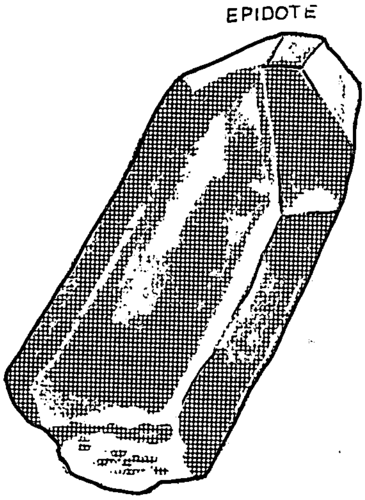
Orthorhombic System

RUTILE



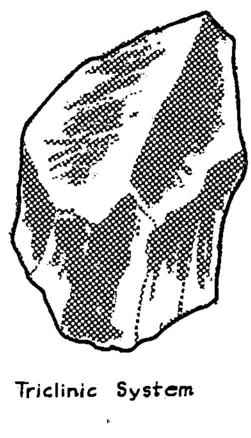
Tetragonal System

EPIDOTE



Monoclinic System

AMAZONITE (or Amazon stone)



Triclinic System

EARTH'S TREASURES: DIAMONDS

BACKGROUND INFORMATION

Diamonds are the hardest known substance. Diamonds can only be cut with another diamond. Millions of years ago, perhaps as long as 100 million years ago, hot liquid rock beneath the Earth's surface was subjected to extreme heat and pressure. Carbon under this kind of extreme pressure became diamonds.

Other properties of diamonds are just as dramatic as their hardness. Diamonds are: resistant to wear; friction-free; transparent to visible, infrared and ultra-violet lights immune to attack from a majority of chemicals; and can be used as a thermal conditioner and an electric insulator.

Approximately 75% of all diamonds mined are used in industry. Many tools/ instruments are made from diamonds: blades for grinders, cutting wheels, optics, etc. Industrial/commercial application is widespread, but in most instances the cost of diamonds is prohibitive.

Space technology has led to the development of a process of coating and chemically bonding an inexpensive supporting material with a thin film of diamond-like carbon.

As a result, the cost of such "diamonds" is far less prohibitive for commercial and industrial purposes, optical instruments, glasses and other consumer products.

ACTIVITY TWO

IDENTIFYING MINERALS: MOHS' SCALE OF HARDNESS

BACKGROUND

The hardness of a mineral is determined by its relative resistance to being scratched. Diamonds are the hardest of all minerals because they will scratch any other mineral when rubbed against it. Talc is the softest of all minerals because all other minerals scratch it.

OBJECTIVES

Young Astronauts will---

1. When given specific minerals, test them for hardness.
2. Explain and demonstrate the MOHS' Scale of Hardness, that follows.

PROBLEM

What is the approximate relative hardness of selected minerals on a scale of 1-10?

MATERIALS

copper penny
nail file
small pyrex plate
mineral chart
rock collection

PROCEDURE (work in pairs)

(Do not confuse hardness with brittleness. If a mineral is harder than number 7, but softer than number 8 on the hardness scale, it will have a hardness of 7.5). (1) Place selected minerals on a small pyrex plate for each student. (2) Put copper pennies and nail files on a common tray for all students to use. (3) Test given minerals for hardness and record results on a rock hardness chart.

EVALUATION

1. What were the hardest minerals?
2. What were the softest minerals?

EXTENDED ACTIVITIES

1. Collect minerals and test them for hardness.
2. Make a rock collection.

MOHS' SCALE OF HARDNESS

Mineral	Simple Test
1. Talc	1. Fingernail scratches it easily.
2. Gypsum	2. Fingernail scratches it.
3. Calcite	3. Copper penny just scratches it.
4. Fluorite	4. Fingernail file scratches it easily.
5. Apatite	5. Fingernail file scratches it.
6. Feldspar	6. Fingernail file does not scratch it; it scratches window glass easily.
7. Quartz	7. Hardest common mineral; it scratches steel and hard glass easily.
8. Topaz	8. Harder than any common mineral.
9. Corundum	9. It scratches topaz.
10. Diamond	10. Hardest of all minerals.

ACTIVITY THREE

FERRO-MAGNETISM

BACKGROUND

One of the most characteristic properties of iron is its ferro-magnetism---strongly magnetic in the presence of a magnetic field set up by a permanent magnet or an electric current.

OBJECTIVE

Young Astronauts will---

1. Test and observe ferro-magnetism.
2. Test and record the "life" of temporary magnets.

PROBLEMS

1. Is the ferro-magnetism greater in an iron nail or a steel nail?
2. Does iron or steel retain temporary magnetism longer?

MATERIALS

iron nails
steel nails
permanent magnets

PROCEDURE

(1) Stroke a permanent magnet with an iron nail in the same direction.
(2) Stroke a permanent magnet with a steel nail in the same direction.
(3) Stroke the nails for the same length of time.
(4) Record the results on a chart.

EVALUATION

1. Look up electromagnets and make one.
2. Test the iron and the steel nail. Are your results the same?
3. Is an electromagnet a temporary or permanent magnet? What happens when the current is removed?

YOUNG
ASTRONAUTS™
USA