NASA
Commercial
Programs

A PROGRESS REPORT 1988

NASA'S Office of Commercial Programs:
Providing a Focus for Action

Space has become an economic frontier, a new territory of commercial opportunity and competition, where private enterprise is adapting to a new environment of untapped resources.

In his 1984 State of the Union message, President Reagan announced a comprehensive plan for space that included as one of its major initiatives a program to stimulate cooperation by government and industry in developing the commercial potential of space.

That same year, the Congress enacted legislation amending the Space Act to establish a new dimension to the mission of the National Aeronautics and Space Administration:

"the general welfare of the United States requires that the National Aeronautics and Space Administration seek and encourage, to the maximum extent possible, the fullest commercial use of space."

An expanded role for the U.S. private sector in America's space future has emerged as a key national objective, and NASA's Office of Commercial Programs is providing a focus for action.

Strengthened by a rich tradition of NASA cooperation with industry, the office supports new high technology commercial space ventures, the commercial application of existing aeronautics and space technology, and expanded commercial access to available NASA capabilities and services.

This report, prepared by the Office of Commercial Programs, Public Affairs Office, highlights the progress NASA has made in carrying out its new assignment.

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To our shareholders:

Every American is a shareholder in our country's space enterprise.

Each citizen has contributed to our national investment in space, an investment which has produced a high-yield return by any measurement. And each American has benefited, in some way, from technological advances and improvements in the quality of life that have resulted from our space program.

This progress report describes how NASA is exercising leadership in seeking ways to increase our economic return from space.

A new era of challenge and opportunity confronts our nation.

We face a disturbing trade imbalance in a changing global economy, and America's once undisputed position of leadership among the world's industrialized nations can no longer be taken for granted. We face capable, determined competitors in the international marketplace.

Yet opportunity abounds. Scientific discovery and technological innovation produce new products and services that can benefit people throughout the world, resulting in entirely new industries.

Space is proving to be a fertile field for such economic growth.

The United States has for some 30 years been a leader among spacefaring nations in conducting space research and in applying the results to practical use. Our success has won worldwide admiration, and inspired other countries to invest in this new frontier. Where we ventured, others followed. Today, space represents a new competitive territory for commercial opportunity and economic expansion.

NASA is working with U.S. industry to ensure that America's hard won space leadership is preserved and advanced. Through these cooperative efforts with American business, NASA is helping to strengthen our nation's economic base, enhance our international competitiveness, and prepare this country for meeting the challenges of the 21st century.

James T. Rose
NASA Assistant Administrator, Commercial Programs

James T. Rose

America's space program has embarked on a new beginning.

Beyond the efforts leading to the Space Shuttle's return to flight, there is a renewal of our commitment to leadership, and a strong new emphasis on the commercial development of space as a national economic asset.

In early 1988, President Reagan signed a new National Space Policy which strongly supports a national goal of creating opportunities for U.S. commerce. He concurrently announced a Commercial Space Initiative which outlines a series of steps to advance this objective.

The 1980s has witnessed an emerging awareness of the potential economic value of space.

Amid a growing consensus that U.S. leadership in the commercial development of space is in the national economic interest, the President directed in 1984 that NASA take steps to significantly expand commercial space activity. The Congress enacted legislation assigning NASA to "seek and encourage, to the maximum extent possible, the fullest commercial use of space."

NASA responded by adopting a Commercial Use of Space Policy and establishing the Office of Commercial Programs (OCP) to provide a focus for action to expand U.S. private sector investment and involvement in the civil space program.

Today, over half of the fifty largest U.S. industrial corporations are participating in one or more of NASA's programs to stimulate commercial space activity.

These top Fortune 500 companies represent a diverse range of commercial interests. Some wish to use space as a new industrial laboratory, a unique place to do research and develop new or improved processes with commercial product potential. Some are pioneering the private development of commercially marketed space

Commercial Space Involvement of Fifty Largest U.S. Corporations

	Company	CCDS Affiliate	Other Participation
1	General Motors	X	
2	Exxon	X	
3	Ford Motors	X	
4	IBM	X	
5	Mobil		
6	General Electric	X	
7	Texaco		
8	AT&T	X	
9	DuPont	X	
10	Chrysler		
11	Chevron		
12	Phillip Morris		
13	Shell Oil		
14	Amoco	X	TEA*
15	United Technologies		TEA
16	Occidental Petroleum		
17	Procter & Gamble	X	
18	Atlantic Richfield		
19	RJR Nabisco		
20	Boeing	X	JEA, MOU, TEA, Other
21	Tenneco	X	
22	BP America	X	
23	USX		
24	Dow Chemical	X	
25	Eastman Kodak	X	
26	McDonnel Douglas	X	Other
27	Rockwell Intl.	X	JEA, TEA, MOU, CPAB, Other
28	Allied Signal	X	
29	PepsiCo		
30	Lockheed	X	
31	Kraft		
32	Phillips Petroleum		
33	Westinghouse Elec.	X	
34	Xerox		
35	Goodyear	X	
36	Unisys		MOU, JEA*
37	3M	X	JEA, TEA, CPAB†
38	Digital Equipment	X	
39	General Dynamics	X	Other
40	Sara Lee		
41	ConAgra		
42	Beatrice		
43	Sun		
44	Georgia-Pacific		
45	ITT		CPAB
46	Unocal		PWA, CPAB
47	Anheuser-Busch		
48	Catepillar		
49	Hewlett-Packard		
50	Johnson & Johnson		

Key:
*Agreement Awaiting Signature
†CPAB Member Retired from Corporation
JEA: Joint Endeavor Agreement
MOU: Memorandum of Understanding
CPAB: Commercial Programs Advisory Board Member
CCDS: Centers for the Commercial Development of Space
TEA: Technical Exchange Agreement
PWA: Proprietary Work Agreement

Sources:
Fortune 500, 4-25-88; Business Week R&D Scoreboard, 6-20-88

Space Shuttle Discovery *poised for launch at Kennedy Space Center's Pad 39-B*

facilities and services. And others are joining an active program to seek out and develop new commercial opportunities.

Only a few of these are firms that are traditionally involved in space projects as contractors to the government. Most are non-aerospace companies, familiar names associated with the types of consumer products people purchase every day.

General Motors, Du Pont, Amoco, Boeing, Eastman Kodak, 3M, Unocal—these giants of U.S. industry are among those that today share a common interest in the commercial potential of space.

Their participation in NASA's programs to encourage the commercial use of space underscores the strong progress that has been achieved in just a few short years, and validates a key strategy of the NASA approach: leveraging the U.S. government investment in space to attract the enormous research and development muscle of U.S. industry.

New Management, Restored Confidence

Fiscal year 1988 opened with a transition to new management in the Office of Commercial Programs.

After a decade of pioneering commercial space manufacturing at McDonnell Douglas Astronautics Company (MDAC), James T. Rose returned to NASA and was appointed to serve as Assistant Administrator for Commercial Programs.

He brought to the job a strong background of aerospace experience in management of both government and industry programs.

Leading MDAC's company-financed efforts to explore the commercial potential of manufacturing pharmaceutical products in space, Rose signed the first industrial Joint Endeavor Agreement with NASA, providing MDAC with access to Space Shuttle flights for astronaut-tended research and development.

During his first year as head of NASA's commercial programs, the focus has been on new initiatives, strategic planning, reorganizing for an active and growing flight program, and an expansion of the NASA-industry partnership.

These efforts have restored confidence in the vitality of the NASA commercial development program, and built a new base for resuming industrial sponsored research in Earth orbit, research that will ultimately lead to the development of new products and services that contribute to America's economic growth.

New Initiatives

Within a few weeks of assuming his new post, Rose announced a program of new initiatives to revitalize the commercial space program in the post-*Challenger* era.

Among these was the establishment of an industry advisory committee, a group to be composed of senior corporate and university executives who would provide NASA with the invaluable viewpoints of business and industry.

In February, the Commercial Programs Advisory Committee was formally created and Edward Donley, Chairman of the Executive Committee, Air Products and Chemicals, Inc., was named to serve as its chairman. A distinguished group of corporate chief executive officers and their university counterparts agreed to serve as members of the committee and the initial meeting of the advisory panel was convened in July.

As a subcommittee of the NASA Advisory Council, the new group will assist NASA by reviewing policies and programs, and recommending strategies to implement the national space policy goals to promote greater investment and participation by the U.S. private sector in America's civil space program.

Another key management initiative of 1988 was the development of a strategic plan for the next quarter century. This comprehensive plan, primarily aimed at meeting the needs and interests of U.S. industry over the next 25 years, is being prepared with the assistance of the American Institute of Aeronautics and Astronautics and a steering committee composed of senior research executives representing diverse industries.

Fiscal year 1988 also witnessed the addition of key management and technical skills in the Office of Commercial Programs to strengthen and enhance the organization's support for new, high-technology commercial space ventures.

The office submitted to agency managers a reorganization plan to support the management and technical requirements of a growing commercial flight program, the implementation of national space policy objectives, and the expansion of a research and technology base that encourages increased commercial participation.

Expanding the Partnership

The NASA-industry partnership was expanded in 1988, with the signing of new cooperative agreements.

In August, NASA and SPACEHAB, Inc. signed a Space Systems Development Agreement to provide six shared Space Shuttle flights for the firm's privately developed and financed middeck augmentation module. The agreement allows the company to pay NASA for standard services on a deferred basis.

The Spacehab module is a truncated cylinder designed to fit in the Shuttle's cargo bay and expand the pressurized volume of the orbiter. Spacehab will provide customers with a variety of locker and rack accommodations, with associated support and integration services. Commercial ventures and sponsored research requiring crew-tended access to the space environment will provide the primary target market.

Another agreement signed in 1988 provides McDonnell Douglas with access to payload processing facilities at the Kennedy Space Center in support of the firm's commercial launch operations, scheduled to begin in 1989. The Office of Commercial Programs negotiated other commercial launch vehicle support agreements with Martin Marietta and LTV.

Unocal, which in 1988 continued its cooperative research and development effort with NASA's Stennis Space Center under a Proprietary Work Agreement, initiated discussions with the Office of Commercial Programs on a proposed Joint Endeavor Agreement (JEA). The firm, which is working on the development of a remote sensing instrument to assist the search for energy resources, has expressed interest in development flights aboard both the Space Shuttle and the Space Station.

The JEA is a no-exchange-of-funds arrangement under which NASA sponsors space flight opportunities for companies that invest corporate resources to test and develop commercially promising concepts.

To facilitate early flight experiment opportunities for the NASA Centers for Commercial Development of Space and their industrial participants, work began this year on the creation of a new agreement mechanism—a pre-joint endeavor agreement.

NASA also negotiated a Technical Exchange Agreement with Amoco, an industrial affiliate of the Center for Advanced Materials located at Battelle Columbus Laboratories.

The family of cooperative agreements provide the framework for accomplishing key commercial objectives: encouraging industry-developed, commercially oriented research and development activities in space; supporting commercial ventures to provide privately financed and constructed space infrastructure and commercial services; and accomplishing the privatization of expendable launch vehicle services.

On June 1, NASA published in *Commerce Business Daily* an invitation for the U.S. private sector to express interest in commercially using the Space Shuttle's jettisoned external tanks. The notice was the first step in implementing one of the specific actions included in the President's Commercial Space Initiative. At present, NASA is conducting negotiations on proposed agreements with several firms.

The Delta *rocket, manufactured by McDonnell Douglas, is now being marketed commercially by the firm, which signed an agreement in 1988 with NASA for use of government processing facilities at the Kennedy Space Center.*

ORIGINAL PAGE
COLOR PHOTOGRAPH

SPACEHAB, Inc.'s commercially developed and financed pressurized module will augment Space Shuttle capabilities. Under a recently signed agreement with NASA, flights of the Spacehab are scheduled to begin in 1991.

Rebuilding a Commercial Flight Program

Industrial participation in the first post-*Challenger* Space Shuttle flight signals the resumption of opportunities for U.S. companies to conduct orbital research projects in cooperation with NASA.

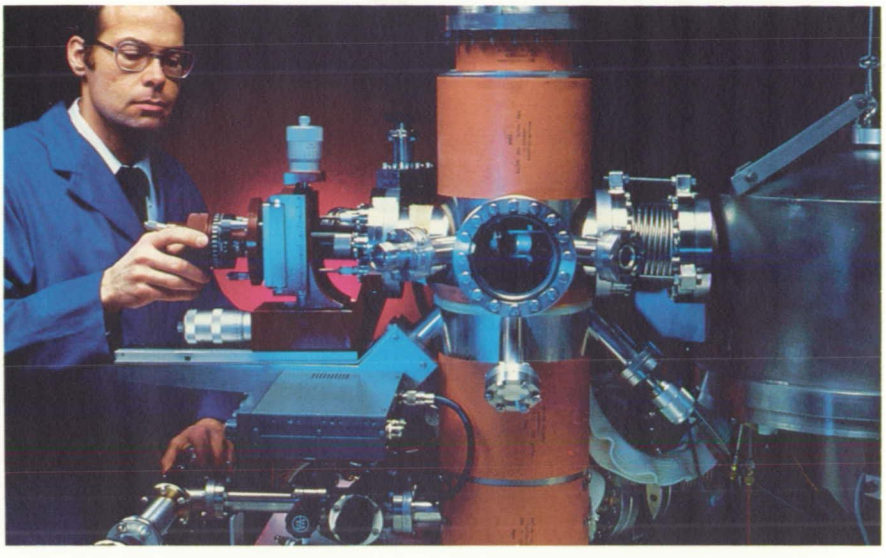
Leading the renewal of industrial research in space are 3M—a joint endeavor partner—and the firms Merck, Upjohn, Du Pont, Schering-Plough, and Burroughs Wellcome—corporate affiliates of the NASA-sponsored Center for Macromolecular Crystallography at the University of Alabama-Birmingham.

These firms are using the unique environment of space to conduct investigations that may lead to new, high-value products and technological advances.

Their experiments will be flown aboard the Shuttle in the crew compartment middeck. The 3M Company and the Center for Macromolecular Crystallography are scheduled to fly again on another Space Shuttle flight in early 1989.

Projections of substantial growth in demand for commercial access to NASA space capabilities has prompted a strengthening of the office's manifesting, integration, and mission management skills.

NASA earlier this year allocated 31 percent of the secondary payload assignments to the Office of Commercial Programs, which has initiated a strong effort to optimize this important, but limited, category of flight opportunities.



Dr. Mark Debe, principal investigator for 3M's space experiment on the 26th Space Shuttle mission, works on lab equipment that will be used to analyze organic thin films produced in orbit.

A more robust flight program will be supported through use of primary payload carriers like Spacehab and Spacelab. Activity is underway to prepare industrial experiments for the planned U.S. Microgravity Laboratory (USML-1) mission, targeted for launch in March 1992.

Commercial payloads sponsored by the Office of Commercial Programs could account for a significant share of NASA's use of the proposed Commercially Developed Space Facility—a Shuttle-tended orbital laboratory endorsed in the President's commercial initiative.

The office is actively engaged in supporting the development of U.S. industrial user requirements for the Space Station *Freedom* and the preparation of new guidelines to encourage commercial involvement in the provision of station infrastructure.

NASA engineers at the Marshall Space Flight Center, Huntsville, Alabama, work on experiment hardware for the STS-26 Protein Crystal Growth payload, which includes industrial investigations by Merck, Upjohn, Schering Plough, DuPont, and Burroughs Wellcome.

Laying a Sound Foundation

Getting U.S. industry into space with the best prospects for long-term commercial success requires laying a sound foundation on the ground.

NASA has established a nationwide network of unique research organizations which combine industrial interest, university talent, and government sponsorship to investigate and develop areas of commercial potential.

These Centers for the Commercial Development of Space (CCDS) serve as incubators for future commercial space ventures, enabling their industrial affiliates to explore the economic value of space in a program where financial and technical risks are shared.

Seven new centers were started in 1988: the Center of Advanced Space Propulsion, University of Tennessee Space Institute; the Center for the Commercial Development of Space Power, Auburn University, Alabama; the Center for the Commercial Development of Autonomous and Man-Controlled Robotic Sensing Systems in Space, Environmental Research Institute of Michigan; the Center for Cell Research, Pennsylvania State University; the Center for Bioserve Technologies, University of Colorado; the Center for Materials for Space Structures, Case Western Reserve University; and the Center for Commercial Development of Space Power, Texas A&M.

A new management initiative undertaken this year seeks to establish a closer linkage between the centers, and enhance the interactions with NASA field centers. CCDS directors are now serving on an operations management working group.

The laboratories and other research facilities of NASA's field centers represent a valuable national asset. By gaining access to NASA's drop towers, research aircraft, and similar facilities, industrial researchers can perform important groundwork that improves the chances of success when space flight opportunities become available.

In 1988, industrial users accounted for approximately half of the total research activity at the NASA Lewis Research Center's Microgravity Materials Science Laboratory, in Cleveland, Ohio.

Commercial use was also substantial this year at NASA's Marshall Space Flight Center in Huntsville, Alabama. Industrial experiments there represented a significant share of total usage of the 100-meter drop tube and flights of the KC-135 microgravity aircraft.

Strengthening U.S. Competitiveness

The NASA resource of technology gained through 30 years of space exploration is helping to strengthen U.S. competitiveness.

The year 1988 marked the 25th year of NASA's widely respected Technology Utilization Program, which has led to thousands of commercial applications of space technology on Earth.

The last two years have seen a dramatic expansion of the NASA technology transfer network, with new linkages to state economic organizations and significant growth in the capabilities of NASA Industrial Application Centers.

The network now reaches into virtually every state of the union, providing easy access for large companies and small businesses alike to NASA technology.

The Technology Utilization Division reported strong, continued progress in the implementation of recent congressional and executive actions aimed at accelerating the transfer of federally funded technology into the private sector. NASA's well-developed program is serving as a model for other agencies as government efforts to assist U.S. industrial competitiveness intensify.

Scientist at the NASA Lewis Research Center's Microgravity Materials Science Lab analyzes a polymer sample. During 1987, industrial users accounted for about half of the total research activity at this NASA facility.

The NASA Structure Analysis (NASTRAN) program was used by a machining manufacturer to design these steam turbine engines, resulting in substantial savings in development costs. NASTRAN is one of five NASA technologies appearing in the newly inaugurated Spinoff Hall of Fame, located in Colorado Springs, Colorado.

Capitalizing on New Ideas from Small Business

The Office of Commercial Programs launched an effort in 1988 to identify new opportunities for American small businesses to capitalize on their innovative ideas by developing commercial applications of space research. Ways to increase small business participation in the commercial development of space are also being actively explored.

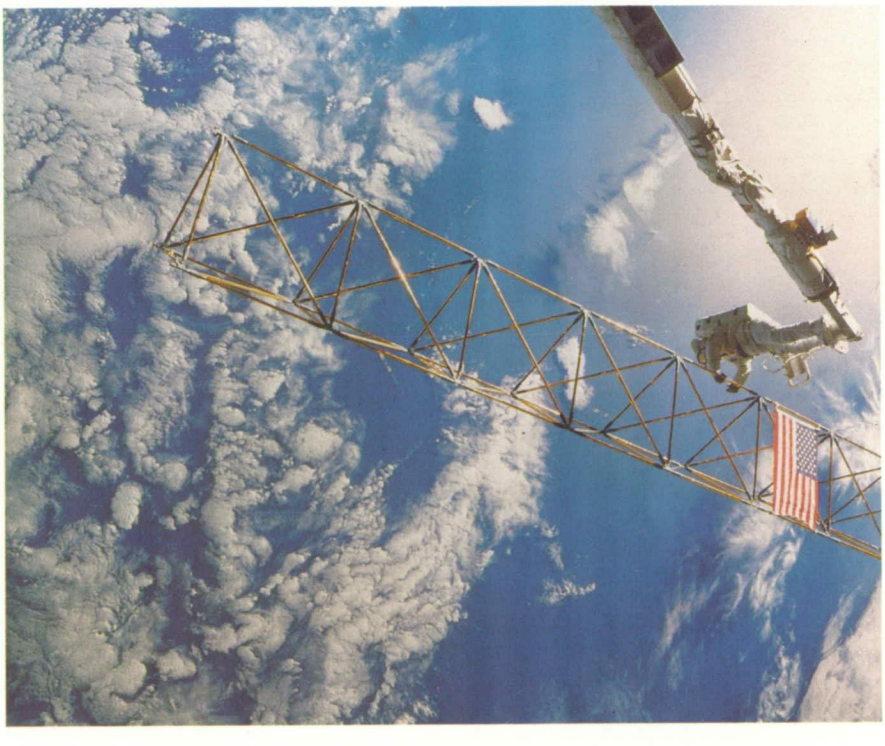
A growing number of small business concerns are initiating new commercial products in many fields as a result of research and development funded through NASA's continuing Small Business Innovation Research Program (SBIR), a program administered by the Office of Commercial Programs. Since 1983, NASA has spent or committed $175 million for 755 Phase I and 299 Phase II SBIR contracts placed with 446 small businesses in 40 states, territories, and the District of Columbia.

During FY 1988, NASA announced the selection of SBIR research proposals resulting in 204 Phase I contract awards from the 1987 Program Solicitation and 85 Phase II awards for continuations of Phase I projects initiated the previous year. Also during FY 1988 the office's Small Business Innovation Research Division completed a comprehensive review assessing the results of Phase II projects completed to date. Many of the results and products are being utilized in NASA programs and several have been successfully commercialized.

New Economic Strength

New methods of transportation have played a key role in expanding our nation's economy. In years past, America's wilderness frontiers were opened for development by the railroad. Air travel has revolutionized international commerce, and aerospace products are today among the strongest U.S. competitors in world trade. In the 21st century, a robust and expanding space economy will be the legacy of our pioneering efforts to venture outward from Earth.

The United States is uniquely capable of leading the exploration and development of space, and NASA's cooperative efforts with U.S. industry offer hope for new economic strength from America's space enterprise.



Commercial Development

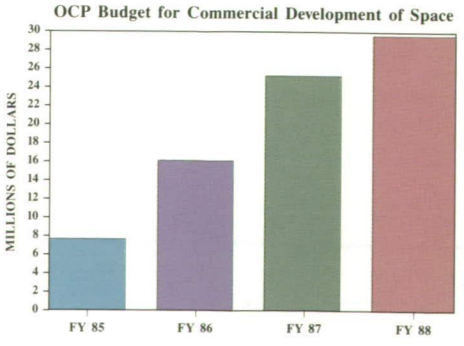
The Commercial Development Program encompasses NASA's diverse activities to seek and encourage the commercial uses of space and to expand the role of the U.S. private sector in civil space activities.

The program saw a renewed vigor in 1988, resulting from the resumption of an active space flight program coupled with major policy and management initiatives.

Commercial Development objectives are met through program activities managed by two Office of Commercial Program divisions: the Commercial Development Division and the Plans, Policy, and Evaluation Division.

Some of these activities include:

- Selecting, funding, and administering the Centers for the Commercial Development of Space.
- Advocating and encouraging the development of a domestic expendable launch vehicle industrial base to provide access to space.
- Negotiating, executing, and funding bilateral or multilateral Space Act agreements in coordination with the appropriate NASA Headquarters program offices and NASA field installations.
- Developing and maintaining relationships with the private sector and fostering opportunities for new commercial uses of space.
- Developing, in conjunction with other NASA program offices, activities which encourage: (a) the commercial application of space technology, (b) commercial ventures resulting from the transfer of NASA functions or capabilities to the private sector, and (c) the use of NASA capabilities and services by the United States private sector.



Centers for the Commercial Development of Space

There are currently 16 Centers for the Commercial Development of Space (CCDS) in operation.

These centers are non-profit consortias of industry, universities, and government which conduct space-based, high-technology research and development in specific areas ranging from materials processing to remote sensing.

As part of its charter to select, fund, and manage these centers, the Commercial Development Division issues proposal solicitations listing various areas of promising space-related commercial R&D.

Following selection, partial "seed" funds of up to $1 million annually are provided until such time as the centers can become fully established and self-sustaining through corporate participation.

Each CCDS also receives scientific and technical expertise,

Centers for the Commercial Development of Space

MATERIALS PROCESSING

Center for Advanced Materials, Battelle Columbus Laboratories, Columbus, Ohio.

Center for Development of Commercial Crystal Growth in Space, Center for Advanced Materials Processing, Clarkson University, Potsdam, New York.

Consortium for Materials Development in Space, University of Alabama-Huntsville, Huntsville, Alabama.

Center for Space Processing of Engineering Materials, Vanderbilt, University, Nashville, Tennessee.

Center for Space Vacuum Epitaxy, University of Houston, Houston, Texas.

LIFE SCIENCES

Center for Macromolecular Crystallography, University of Alabama-Birmingham, Birmingham, Alabama.

Center for Cell Research, Pennsylvania State University, University Park, Pennsylvania.

Center for Bioserve Space Technologies, University of Colorado, Boulder, Colorado.

REMOTE SENSING

Center for Mapping, Ohio State University, Columbus, Ohio.

ITD Space Remote Sensing Center, National Space Technology Laboratories, Mississippi.

AUTOMATION AND ROBOTICS

Center for Space Automation & Robotics, University of Wisconsin, Madison Wisconsin.

Center for the Commercial Development of Autonomous and Man-Controlled Robotic Sensing Systems in Space, Environmental Research Institute of Michigan, Ann Arbor, Michigan.

SPACE PROPULSION

Center for Advanced Space Propulsion, University of Tennessee Space Institute, Tullahoma, Tennessee.

SPACE STRUCTURES AND MATERIALS

Center on Materials for Space Structures, Case Western Reserve University, Cleveland, Ohio.

SPACE POWER

Center for Commercial Development of Space Power, Texas A&M Research Foundation, College Station, Texas.

Center for the Commercial Development of Space Power, Auburn University, Auburn, Alabama.

opportunities for cooperative activities, and other forms of continuing assistance.

Through the centers, NASA is able to advance basic and space-related commercial R&D, promote and facilitate commercial space ventures, and cultivate strong ties with industry.

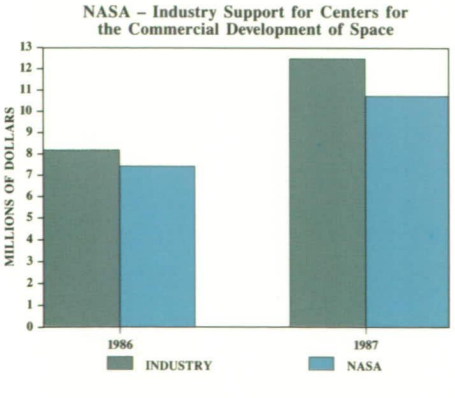
The efforts in 1988 of a team of industrial researchers affiliated with the Center for Macromolecular Crystallography, University of Alabama- Birmingham, clearly evidence the value and potential of this program.

The team's experiment aboard STS-26 could lead to commercial, in-space production of tiny protein crystals.

Protein crystals grown in space could become vitally important research tools for scientists who are working to develop powerful new drugs to combat cancer, high blood pressure, organ transplant rejection, rheumatoid arthritis, and many other diseases.

Another center, the Consortium for Materials Development in Space, University of Alabama-Huntsville, is leading efforts to conduct materials processing research aboard a commercially provided sounding rocket.

The sounding rocket, scheduled for launch in the first part of 1989, will carry a payload of instruments to perform materials processing experiments in the low-gravity environment of space. In keeping with the Commercial Space Launch Act, the consortium plans to award a competitive contract for launch services.



Tiny crystals of the protein Concanavalin B are seen here growing in the microgravity environment of space during the January 1986 flight of Columbia. *The NASA-sponsored Center for Macromolecular Crystallography, a Center for the Commercial Development of Space, and its industrial affiliates conduct orbital experiments in the growth of protein crystals, important research tools that can lead to new life-saving drugs.*

One of the most impressive accomplishments of the centers to date continues to be the 1986 superconductivity breakthrough by two scientists associated with NASA'S CCDS program. That breakthrough, in which scientists were able to raise the temperature at which material becomes superconductive—thereby reducing the costs associated with coolants required for this work—has led to further advancements in this field.

In 1988 one of the same scientists, Dr. Paul Chu, of the Center for Space Vacuum Epitaxy, University of Houston, advanced research in this area even further with his discovery of a material which is superconductive at an even higher temperature.

Although the superconductivity breakthroughs received worldwide attention, impressive R&D accomplishments have been made at many of the centers.

CCDS accomplishments include some 615 drop tube/tower microgravity experiments conducted, 21 KC-135 microgravity flight experiments, involvement in four Space Shuttle flights, one series of Lear Jet flights, and five experiments prepared for a sounding rocket flight.

Since initiation of the program in 1985, participation and interest has steadily risen, with the number of CCDS industrial affiliates now totaling well over 100.

In 1989, an increased emphasis will be placed on providing CCDS industrial affiliates with opportunities for early flight experiment ventures through the use of new agreements. In the future, NASA envisions that each center will engender at least five Joint Endeavor Agreements.

Expendable Launch Vehicle Privatization

Assuring a highway to space by fostering growth of a U.S. commercial launch industry is one of the key initiatives of the President's new national space policy. Over the past few years, NASA's efforts to advocate and encourage development of an expendable launch vehicle (ELV) industrial base have helped make commercial space transportation services a reality.

NASA's signing in 1987 of the first agreement transferring operation of a government-developed ELV to the private sector marked a major milestone in these efforts. The agreement was with General Dynamics Corp. for operation of the Atlas Centaur vehicle.

Kennedy Space Center has entered into a related agreement with General Dynamics allowing the company to use NASA Launch Complex 36 and associated facilities for commercial launch operations of the Atlas Centaur vehicle.

In 1988, NASA and the Department of Commerce made history with their award of a $200 million contract to General Dynamics to provide ELV transportation services for the National Oceanic and Atmospheric Administration's family of geostationary operational environmental satellites, marking the first U.S. government procurement of commercial launch services.

NASA also signed this year an agreement with McDonnell Douglas Astronautics Company, manufacturer of the commercial Delta launch vehicle, for use of Kennedy Space Center payload processing and launch facilities.

Similar agreements are also being negotiated with Martin Marietta, producer of the Titan, and LTV, which builds the Scout vehicle.

NASA's efforts to assist the startup of new, privately developed launch vehicles by entrepreneurial firms is demonstrated by the agency's 1987 Memorandum of Agreement with Space Services, Inc., for use of NASA's Wallops Flight Facility in Virginia. The company plans to begin commercial launches of their Conestoga vehicle in 1989. A similar agreement with Conatec was under negotiation.

Further support for the new industry comes from NASA's adoption in 1988 of a mixed-fleet plan, in which unmanned launches, purchased by NASA as a commercial service, will complement Space Shuttle operations. A need has been identified for 30 such government purchased launches through 1994.

An Atlas-Centaur rocket rises from its Cape Canaveral launch pad. Developed by NASA as a government launch vehicle, the Atlas-Centaur has been privatized through an agreement between NASA and General Dynamics, its manufacturer. General Dynamics will privately produce the booster and market commercial launch services.

Support for New High-Tech Commercial Ventures

In 1988 Commercial Development also sought to increase and broaden its support for new high-technology commercial space ventures by coordinating NASA's negotiation, execution, and funding of a variety of bilateral and multilateral agreements with industry.

Activities in this area were aimed not only at increasing the number of agreements signed, but also at reviewing the type of agreements presently offered and anticipating the types of agreements which will be needed in the future to facilitate growth of a vigorous U.S. commercial space industry.

At present, NASA utilizes a number of innovative and functional agreements which provide industry with assistance, services, and facilities to help reduce the risks associated with commercial space ventures.

This family of agreements include:

- Joint Endeavor Agreements, which involve no exchange of funds and are designed to encourage early space ventures and demonstrate the use of space technology to meet marketplace needs. Private industry funds the experiments and NASA provides transportation and other services.

- Space Systems Development Agreements, providing industry with a deferred payment schedule for Shuttle launch services. This allows the entrepreneur to have a more favorable cash flow during a time when capital investment costs are typically the greatest. This agreement is designed to encourage new uses of space and is, therefore, available only for the first flight or series of flights of the first entrant into a new industry.

- Technical Exchange Agreements, designed for companies interested in applying microgravity or other technologies, but not ready to commit to a specific space flight experiment or venture. Under the agreement, NASA and a company agree to exchange technical information and cooperate in the conduct and analysis of ground-based research programs. The

Major NASA-Industry Cooperative Agreements Currently Active

Space Systems Development Agreements (SSDA)

SPACEHAB, Inc.
Geostar Corporation
Space Industries Partnership

Joint Endeavor Agreements (JEA)

3M
Boeing Aerospace Corporation
Grumman Space Systems
International Space Corporation
Instrumentation Technology Associates
Martin Marietta Corporation
Microgravity Research Associates
Rockwell International

Memoranda of Agreement

Space Services, Inc.
Institute for Technology Development
Scott Science and Technologies, Inc.

Other

General Dynamics Corporation
Martin Marietta Corporation
Orbital Sciences Corporation
Fairchild Industries Corporation

Not included are a number of Technical Exchange Agreements, Memoranda of Understanding, and participants in the Industrial Guest Investigator program.

company funds its own participation, while gaining direct access to and results from NASA facilities and research. NASA benefits from the knowledge derived as a result of the cooperative effort.

▶ Other agreements, such as Memoranda of Understanding and Memoranda of Agreement, provide a framework for uniquely meeting specific commercial interests.

Further Efforts

NASA is also working closely with industry to explore the potential commercial uses associated with the Space Station *Freedom,* an orbiting complex of modules to be assembled in the 1990s.

In November of 1987, NASA officials met with more than 200 corporate executives, representing diverse industries, to discuss how the Space Station can best meet future industry needs.

Input from this conference is being used in formal NASA reviews of Space Station user requirements as work proceeds toward detailed design and development of the orbital facility. A second Space Station commercial user workshop is planned in October 1988.

In addition, NASA officials met with Space Station work package contractors to discuss ideas for commercializing certain station operations in the initial phase.

NASA has also invited companies to investigate, with the agency, the potential for commercial participation in station facilities and services.

New policy and planning initiatives to review pricing policies, commercial participation in the development of space infrastructure, and criteria for assessing proposed commercial ventures were also begun in 1988. These activities will continue into FY 1989 to further develop NASA's capabilities to respond to commercial interest in space.

Responding to increased interest and activity in Earth and ocean observations from space, NASA's Stennis Space Center in Mississippi has been designated the lead center for commercial remote sensing.

Potential commercial applications of remote sensing—the process in which satellite or airborne sensors detect various types of radiation emitted by, or reflected from, objects on Earth—continue to increase.

In 1988 NASA selected for funding some twenty application projects in this area, nine of which will be managed by Stennis Space Center's Earth Resources Laboratory (ERL). ERL is currently exploring ways to use existing remote sensing technology in new commercial products and services, and is also helping users develop their own technology. Eleven other projects are being managed by NASA's Office of Space Science and Applications. These projects involve remote sensing technology development for public sector applications.

Technology Utilization

For 25 years, NASA's Technology Utilization Program has been dedicated to promoting and facilitating the application of NASA-developed technologies in the public and private sectors.

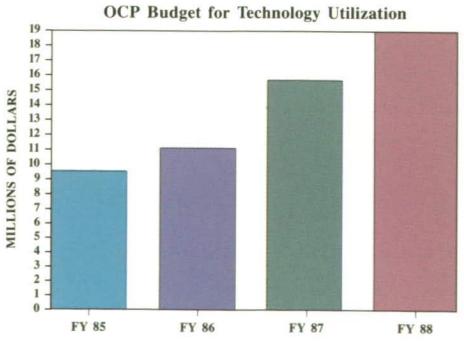
Building on a solid record of accomplishment in technology transfer, the NASA program is well prepared to meet the challenge of a new federal emphasis on increasing the transfer of government-funded technologies to the private sector as a means of improving U.S. industrial competitiveness.

Recent congressional legislation and executive orders have directed federal agencies to heighten their efforts to move new technologies into the U.S. private sector.

One of NASA's first responses was to conduct a thorough review of its program, which has already produced thousands of successful aerospace and non-aerospace "spinoffs" ranging from improved medical care to energy conservation.

From that review, a new strategic plan has emerged to serve as a guideline for present and future NASA technology transfers.

Major steps were taken in 1988 to strengthen and expand the scope of NASA's technology transfer network and the various mechanisms which it comprises. In addition, a series of new initiatives were implemented by the Technology Utilization Division to ensure further progress in advancing the objectives of specific congressional and executive actions in this area.



NASA-developed technology to reduce drag on jet aircraft was adapted for use on the Stars and Stripes *(US-55), and helped to return the America's Cup home. NASA's rich resource of technology is also helping to boost U.S. industrial competitiveness.*

A Nationwide Network

Over the years, NASA's technology transfer network has provided thousands of industrial, university, and government clients with access to NASA-derived technology, information, and personnel, producing thousands of successful spinoffs. These spinoffs have resulted in new and improved goods and services for the American public, stimulating our economy through the generation of new jobs and dollars.

Today, this network reaches into virtually every state of the union.

NASA's group of 10 Industrial Application Centers (IAC) and their affiliates form the heart of this system. Recognizing this, NASA sought in 1988 to significantly increase the capabilities of these centers, which disseminate NASA-developed technology to a broad range of industrial clients by providing them access to nearly 100 million scientific and technical documents in the NASA data bank. IACs are also provided access to more than 600 other computerized data banks, as well as NASA scientific and technical personnel.

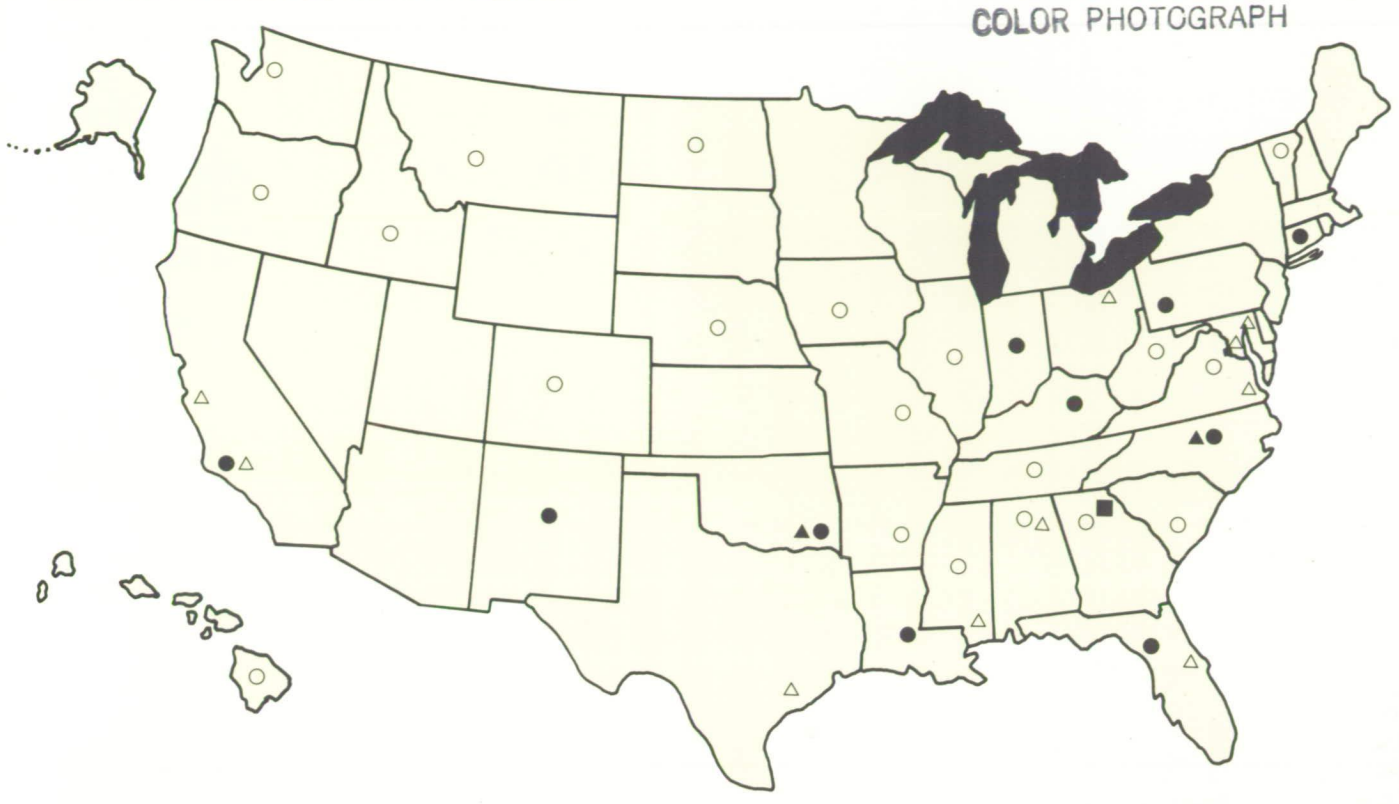
In addition to expanding the IAC's reach to include links with state-sponsored institutions throughout the country, the NASA Technology Utilization Program entered into a blanket agreement with the Federal Laboratory Consortium connecting IACs and their affiliates to the consortium's network of 500 research and development labs and its clearinghouse.

This agreement has made it possible for U.S. industries and entrepreneurs, using access points within their home states, to find out what federal technology, relevant to their needs, is available in federal laboratories throughout the nation.

Additionally, NASA plans to make the IAC network accessible to clients of other federal and state-supported industry assistance activities, including the more than 500 Small Business Development Centers, Economic Development Agency Centers, and the proposed Hollings Centers under the aegis of the National Bureau of Standards.

Other recent highlights of the progress of these centers include a contract signing with Southern University, Baton Rouge, Louisiana, to operate an IAC and provide dissemination/information services primarily in Louisiana and Mississippi, marking the first minority university to join the IAC network.

NASA's Technology Transfer System



△ *Field Center Technology Utilization Officers:* manage center participation in regional technology utilization activities.

● *Industrial Applications Centers:* provide information retrieval services and assistance in applying technical information relevant to user needs.

○ *Industrial Applications Center Affiliates:* state-sponsored business or technical assistance centers that provide access to NASA's technology transfer network.

■ *The Computer Software Management and Information Center (COSMIC):* offers government-developed computer programs adaptable to secondary use.

▲ *Application Team:* works with public agencies and private institutions in applying aerospace technology to solution of public problems.

Although no overall price tag can be placed on the value of the services provided by IACs, an example of their benefit is evident in $1.25 million saved by the city of Albuquerque, New Mexico, when it utilized the services of the Technical Application Center (TAC), an IAC which specializes in remote sensing and imaging technologies. TAC provided the city with aerial photographs of an area where a bridge was to be built. The photos allowed the U.S. Army Corps of Engineers, who designed the bridge, to shorten it by 500 feet, thereby reducing its cost.

Sharing Human Resources

NASA's technology transfer system is also supported by one of the agency's most valuable resources—NASA personnel.

Within the network, NASA employees serve as technology transfer guides. Technology Utilization Officers are placed at each NASA field center. They work with industry, providing information on new technologies developed at the center and matching and cross-correlating NASA technologies with industrial needs. They also provide a link to NASA's engineers and scientists, who can help clients locate, adapt, and implement NASA technology.

Because of the importance of industry access to expert sources of information, in fiscal year 1989, NASA plans to strengthen the technology counselor network at field installations.

In addition, to facilitate timely and efficient interaction between technology counselors, IACs, and other organizations in the NASA technology transfer network, a microcomputer-based information and communications system is planned to encourage and facilitate new technology identification, acquisition, and evaluation.

An ADA software repository and software value-added capability is also being developed in cooperation with the Department of Defense's Joint Projects Office and the Department of Commerce. A technology transfer component will adapt ADA software for application in such areas as flexible computer integrated manufacturing, automation and robotics, and artificial intelligence.

Spreading the Word

NASA's *Tech Briefs,* a publication containing concise descriptions of innovations arising from NASA research and development efforts, has long been a key component of the technology transfer network. Distributed to some 200,000 subscribers annually, it identifies and highlights information on new aerospace technologies which appear to have potential non-aerospace uses.

The publication, which began as a NASA-produced one page "Flash Sheet" describing new technologies, has evolved into a commercially produced magazine which has published nearly 13,000 new technology reports since its inception. In response to published *Tech Briefs,* more than one and a half million requests from readers have been submitted for Technology Support Packages which provide more detailed information on specific technologies. Reader feedback indicates that dollar savings to industy and government clients are running in the millions. To respond to increased demands, beginning in 1989, the number of issues published per year will increase from 10 to 12.

Likewise the scope and significance of NASA *Spinoffs,* an annual publication, continues to grow and enhance the technology transfer network. The publication reported some 50 new spinoff items this year, with more than 600 highlighted since its inception.

The public visibility of NASA's many space technology spinoffs is also increasing, as evidenced by numerous trade and media articles and the recently inaugurated Spinoff Hall of Fame in Colorado. Sponsored and managed by the U.S. Space Foundation, the Spinoff Hall of Fame was officially opened in 1988 with the selection of five NASA technologies.

A special thin, light, flexible, yet durable and noncombustible fabric developed for space suits provided the basis for later development of heavier construction-use fabrics with similar advantages. The first adaptation was Michigan's Silverdome. The relatively low cost of these fabrics has inspired widespread acceptance of fabric-roofed structures in shopping malls, stadiums, field houses and other facilities.

Supporting Technology Applications

NASA directly supports technology application efforts, which are geared toward the solution of public and private sector problems that have been identified by user organizations at the federal, state, and local levels.

Currently some 60 technology application projects are underway at nine NASA field installations in a variety of disciplines including: automation and robotics, bioengineering and biotechnology, advanced materials and composites, electronics and semiconductors, and rehabilitation.

One such project initiated in 1988 is a joint effort between NASA and the Johns Hopkins Wilmer Eye Institute to use space technology to develop a device designed to improve the sight of millions of people with poor vision.

Application projects were first established in 1970 to provide direct NASA assistance and primary funding to promote secondary use of aerospace technology. They involve cooperative efforts to build and test prototype hardware if the industrial partner agrees to provide partial funding and is prepared to complete marketing of the transfer. To date more than 150 projects have been initiated and 75 successful transfers have been completed.

Technology application teams, which specialize in a particular area of application, were established in 1971 to provide concentrated technical assistance to industry clients. At present, two such teams are operating, Research Triangle Institute and Rural Enterprises, Inc.

In FY 1989, NASA plans to broaden application team responsibilities for brokering industrial clients' needs, particularly those in the manufacturing sector, and matching such needs with NASA technology.

Responses to New Legislative Challenges

As a long time leader among U.S. government agencies in technology transfer efforts, NASA has welcomed the recent federal emphasis in this important area.

To further respond to the recent congressional legislation and executive direction regarding technology transfer, NASA officials implemented in 1988 a series of new initiatives aimed at compliance with the recent mandates. The initiatives were developed following a review of the program which was conducted not only to determine how best the agency could comply, but also how it could retain its traditional leadership status among federal agencies in the area of technology transfer.

Highlights of accomplishments made toward further compliance with recent legislation include:

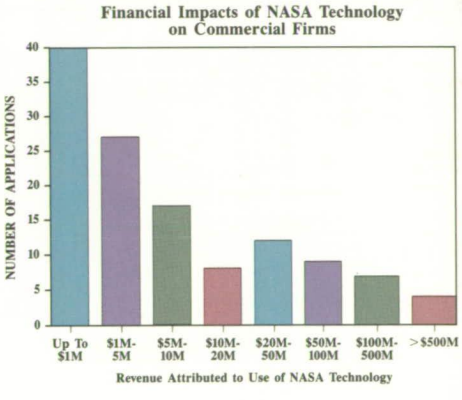
- Participation in the Federal Laboratory Consortium for Technology Transfer, as well as transfer of NASA funds to support the project.
- Establishment of the Ames University Consortium, created to provide reciprocal use of services, personnel, equipment, and facilities between NASA's Ames Research Center and member institutions, presently including relationships with 136 universities nationwide.
- Cooperation with RIMTECH (Research Institute for the Management of Technology), a consortium of technology based businesses in southern California organized to provide systematic access to the technology of NASA's Jet Propulsion Laboratory.
- Distribution of patent royalty income to present and former NASA employee-inventors and distributing a share of these funds to appropriate NASA field centers.
- Granting of 167 awards to date to NASA and NASA contractor personnel for scientific and technical contributions which have "significant value in the conduct of aeronautical and space activities." Some of these were directly influenced by the degree of technology transfer and commercialization achieved for nonaerospace industrial purposes.
- Expansion of cooperative efforts for technology transfer with other organizations, including many of the initiatives mentioned above, as well as participation in the Technology Share Project and the establishment of a High Temperature Superconductivity Working Group. The superconductivity group will coordinate on-going NASA superconductivity research at NASA field centers, assess the impact of new superconducting material on aerospace technology and missions, and determine and recommend to NASA its role in this emerging field. The group is also coordinating its activities with other major federal agencies.

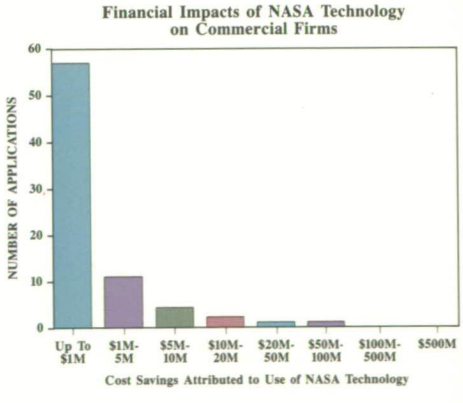
Assessing the Impacts

In addition, an effort was undertaken in 1988 to assess the economic impact of some of the NASA-derived spinoffs or applications reported in NASA's *Spinoff* publication between 1978 and 1986.

Although tangible statistics on the economic impact of technology transfer are often difficult to measure or summarize, researchers tracing nearly 350 applications publicized in *Spinoff* annual reports have obtained estimated revenues and cost savings that may be attributed in part or in whole to NASA programs.

These NASA spinoffs have resulted in economic benefits from contributions to sales or savings approximating $27 billion since 1978. While work on the study is still in progress, findings thus far dramatically illustrate the benefits of technology transfer to both industry and the nation at large.





These charts, derived from data collected on nearly 250 applications of NASA technology, illustrate the dollar impacts of revenues and cost savings associated with the commercial application of space technology.

Source: Technology Utilization Division, OCP, NASA, Preliminary Study Results

Small Business Innovation Research

NASA's Small Business Innovation Research Program (SBIR) is designed to increase small business participation in NASA programs.

In 1988 the program experienced continued growth, with an increase in funding, proposals received, and contracts awarded. An ambitious assessment was also undertaken to review the program's status and progress, as well as to help NASA management determine a future course.

The program was instituted in 1983 to comply with congressional SBIR legislation and policy guidelines established by the Small Business Administration.

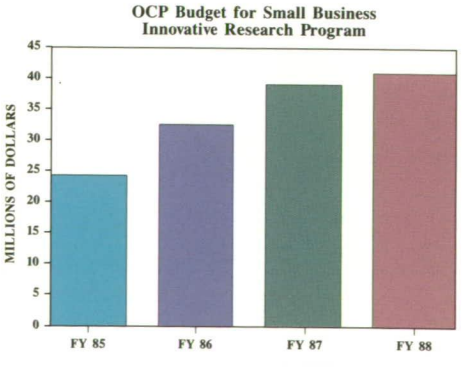
NASA finances SBIR by setting aside one and one-quarter percent of its annual research and development appropriation for the award of Phase I and Phase II contracts to small businesses. Proposals are requested annually in areas of interest to the agency, many of which have commercial potential. Contracts are placed and projects are managed by nine NASA field installations across the country.

Specifically, NASA's SBIR Program and SBIR legislation seeks to stimulate U.S. technological innovation, increase the participation of small businesses in federal R&D programs, foster greater participation of minority and disadvantaged persons, and increase commercialization in the private sector of innovations derived from federal R&D.

To meet these objectives, the program undertakes a number of activities including:

Biospherical Instruments, Inc.'s moored oceanographic spectroradiometer, a commercially successful SBIR project developed under contract to NASA's Jet Propulsion Laboratory, is shown being maintained by a diver off the coast of La Jolla, Calif.

- Formulating policies, and developing, overseeing, evaluating, and implementing NASA SBIR activities which encourage U.S. private sector participation in civil space activities.
- Selecting and funding small business activities that directly support NASA program objectives and requirements.
- Increasing the small business community's awareness and participation in NASA's SBIR and other programs.
- Developing a synergy between the NASA SBIR program and other Office of Commercial Program objectives and programs.



Assessing Progress

In 1988 an assessment of the program was conducted to establish the basis for an agency position on SBIR, which was transmitted to the General Accounting Office. The assessment also provided timely information to NASA management on the program's status and the degree to which SBIR projects are proving to be of value to NASA.

The review focused on 73 Phase II contracts which were completed or nearing completion. During the review, program officials gathered data and comments from both NASA field center personnel and small business participants to evaluate support for the SBIR Program, the value of research conducted in the program, and the potential NASA and commercial applications of the research, as well as other variables.

A number of encouraging findings have been revealed.

Specifically, the assessment found that almost unanimous support exists among NASA and small business personnel for the program.

Both groups overwhelmingly rated the quality of research conducted in the program as being as

Biospherical Instruments, Inc.'s sensors, which measure ambient light below the ocean's surface, are shown being lowered into South Pacific waters from the Calypso. *The instrument was tested during a cruise sponsored by the Cousteau Society.*

high or higher than the majority of research conducted in other government or NASA programs.

Out of the 73 projects studied, NASA personnel rated 24 of the projects as better than average in quality and 34 as equal in quality.

Likewise, 60% of the company officials rated the quality of their research conducted in SBIR to be higher than in other government projects they have conducted. Reasons given included a sense of personal commitment to an idea of their own, the incentive provided by the focus on a product having commercial potential, and adequate funding, along with a definite schedule for completion.

The projects studied were also found to have significant applications by NASA. NASA personnel judged more than half of the projects to have either immediate applications in NASA missions or good prospects for being chosen within five years.

The assessment also disclosed that successful commercial applications are developing from the projects. Some 22 percent of the projects were said by small business officials to be well along in the commercialization process. Another 12 were judged by company officials as having good prospects for generating marketable products.

An example of the commercial and scientific benefits of one of the first completed SBIR projects is evident in the moored oceanographic spectro-radiometer developed by Biospherical Instruments, Inc. under contract to NASA's Jet Propulsion Laboratory.

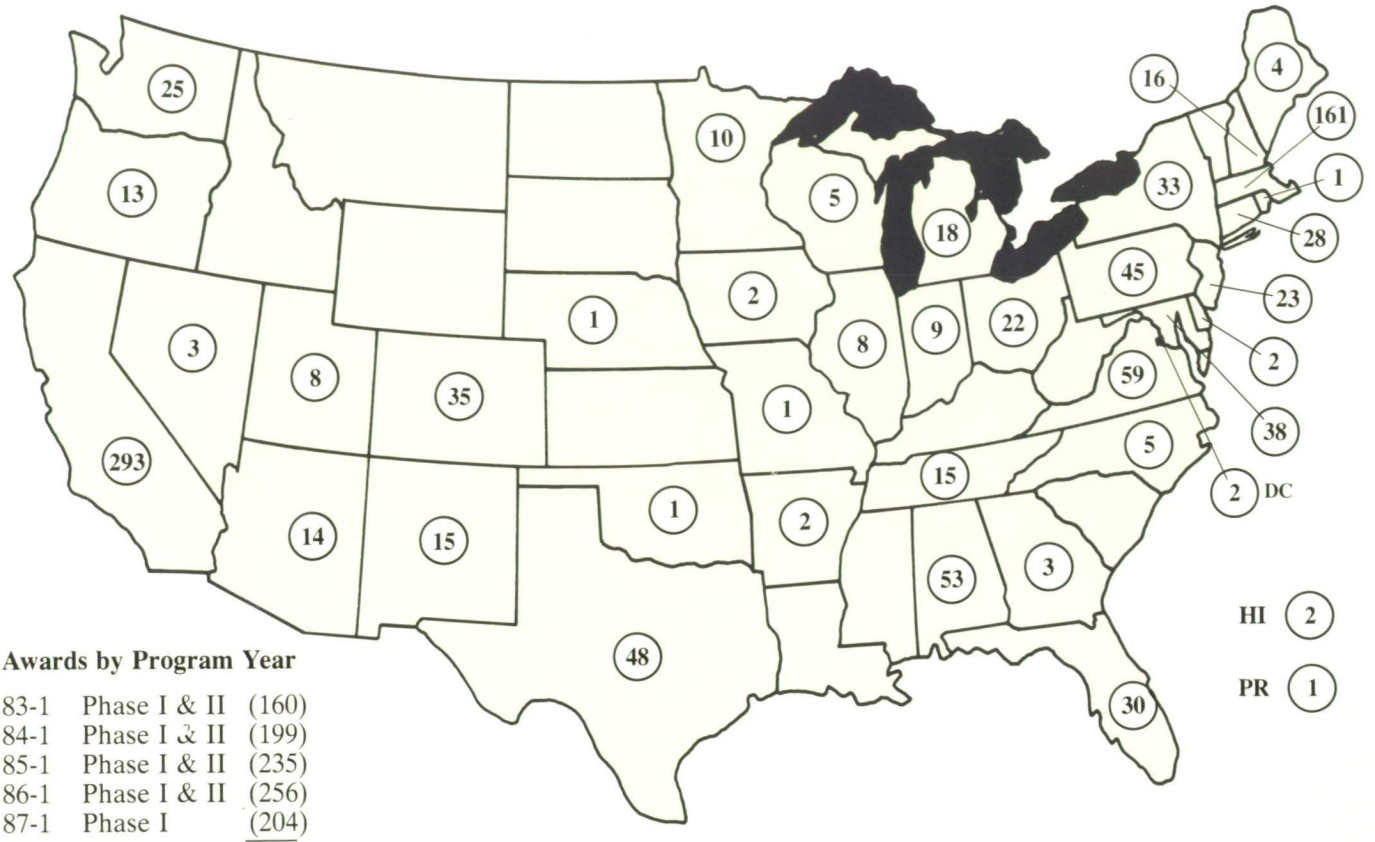
The optical instrument system, which was designed to provide spectral data on sunlight reflected in the ocean, is now the standard for long-term monitoring of the ocean's surface. The system provides ground-truth data for future NASA missions in oceanography. To date, 12 systems have been sold commercially and many more sales are anticipated in the U.S. and overseas. The project has also become the basis for expansion of this business and company development of additional optical sensing capabilities.

NASA SBIR Award Distribution by State

	PHASE I				PHASE II						
Program Solicitation Year	Proposals	Awards	Total Funding $M	Average Funding $k	Proposals	Awards	Total Funding $M	Average Funding $K	Phase III Funding Commitments Total	Phase III Funding Commitments Awards	Total Program Funding $M
1983	977	102	4.93	48.3	92	58	23.77	410	54	37	28.70
1984	919	127	6.23	49.1	113	71	32.91	463	62	38	39.14
1985	1164	150	7.43	49.5	129	85	40.48	476	55	41	48.91
1986	1628	172	8.5	49.4	154	85	40.49	476	NA	NA	48.99
1987	1826	204	10.1	49.2	NA	NA	NA	NA	NA	NA	NA
TOTALS TO DATE	6514	755	37.2	49.4	488	299	137.65	460	171	116	164.74(1)

NOTE: (1) Total program funding is for first four program solicitation years, Phase I plus Phase II

NASA SBIR Award Distribution by State



Awards by Program Year

83-1	Phase I & II	(160)
84-1	Phase I & II	(199)
85-1	Phase I & II	(235)
86-1	Phase I & II	(256)
87-1	Phase I	(204)
		1054

Selecting and Funding Innovative Ideas

SBIR activities in 1988 to select and fund small business ventures that support NASA missions culminated in the issuance of the sixth annual SBIR Program Solicitation. The solicitation invited qualified small businesses to submit proposals in response to 150 subtopics contained in 15 Technical Topic areas.

Each subtopic described research problems or desirable innovations which could assist NASA in its mission. Many of these innovations could also lead to commercial applications for the small businesses.

The 1988 solicitation is expected to result in more than 200 Phase I contracts, totalling $10 million. These contracts have a maximum value of $50,000 each and six-month durations to investigate the feasibility of innovative ideas proposed in response to the solicitation.

In 1989, about half of the Phase I projects selected in 1988—those which show the most promise and value to NASA at completion—will be selected competitively for two-year, follow-on Phase II contracts, valued at up to $500,000.

From the 1987 program solicitation, $40 million in SBIR funding was used to fund 204 Phase I contract awards and for incremental funding support of 170 Phase II contracts resulting from the previous two annual solicitations.

Since 1983, the agency has spent or committed $175 million for 755 Phase I and 299 Phase II contracts placed with 446 small businesses in 40 states, territories and the District of Columbia.

The program continues to attract increasing interest among small business community members. The number of proposals received from annual solicitations more than doubled since initiation of the program, increasing from 977 proposals submitted in 1983 to 2,379 in 1988.

To further draw the talent and creativity of this labor pool to its missions, NASA undertook new efforts in 1988 to increase the small business community's awareness and participation in SBIR and other programs.

In addition to attracting these firms through annual requests for proposals, the agency is presently working with the Small Business Administration to develop linkages between the NASA Industrial Application Network and Small Business Development Centers.

Small Business Links to the Commercial Development of Space

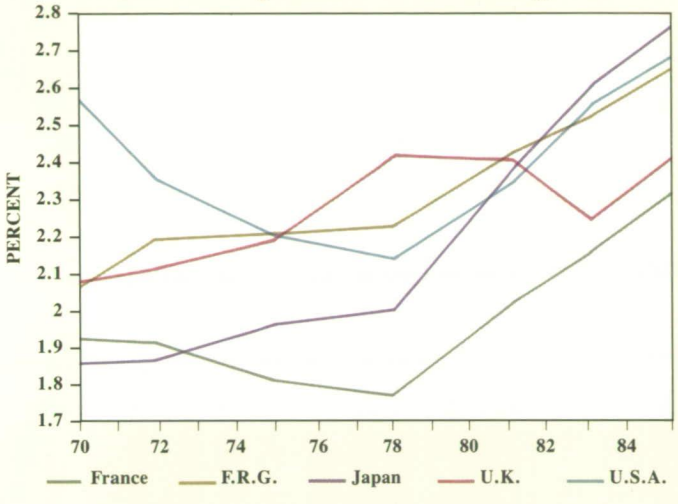
New efforts were also undertaken in 1988 toward developing further synergy between the NASA SBIR Program and other Office of Commercial Program objectives and programs.

The 1988 SBIR solicitation included several subtopics which were directly related to commercial space applications. OCP may issue a special solicitation on commercial space opportunities at a later date, depending on the response to this solicitation and on the possible development of new ways to assist small businesses in developing the commercial potential of their projects.

The charts and graphs included in this section characterize key international and domestic trends in research and development expenditures. International comparisons focus on spending by major U.S. trading partners which are also active in space research and commercial applications.

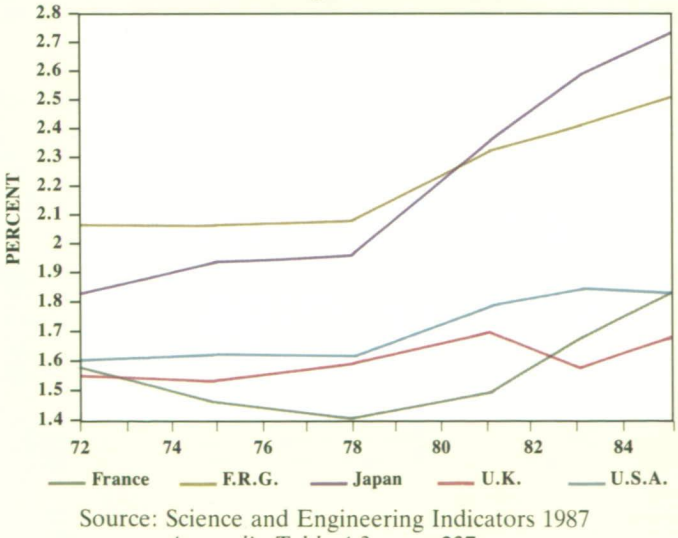
Space sector data demonstrates the major importance of the high technology aerospace industry to the U.S. balance of trade. Also included is information on the emerging U.S. commercial launch vehicle industry and its competitive position.

Total R&D Expenditures as a Percentage of GNP



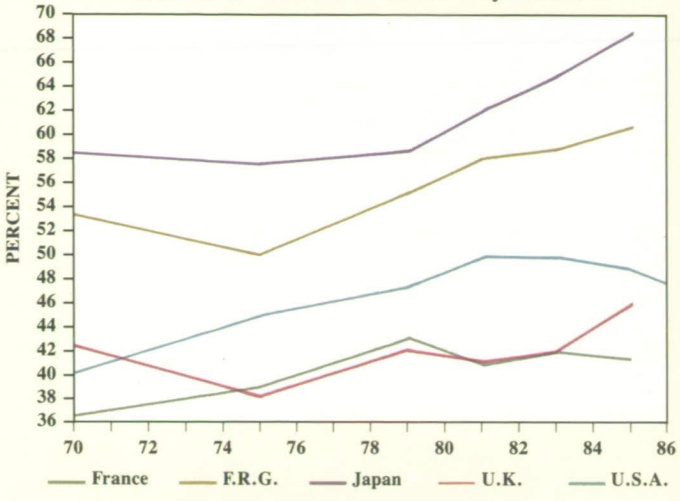
Source: Science and Engineering Indicators 1987
Appendix Table 4-2, page 236

Non-Defense R&D Expenditures as a Percentage of GNP (Estimated)



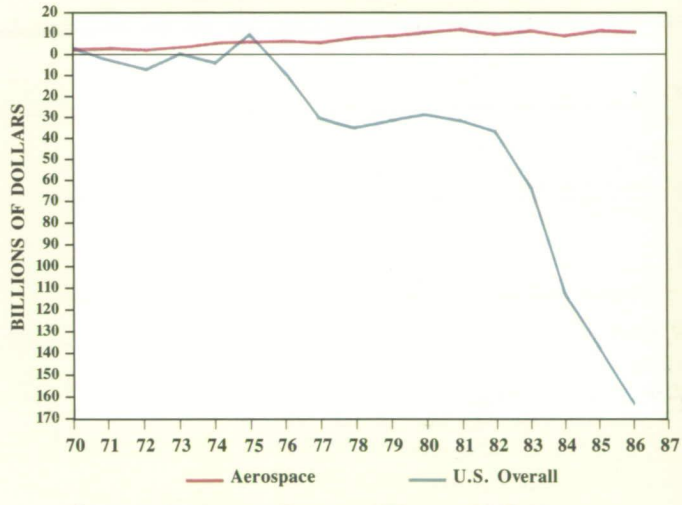
Source: Science and Engineering Indicators 1987
Appendix Table 4-3, page 237

Percent of Total R&D Funded by Business



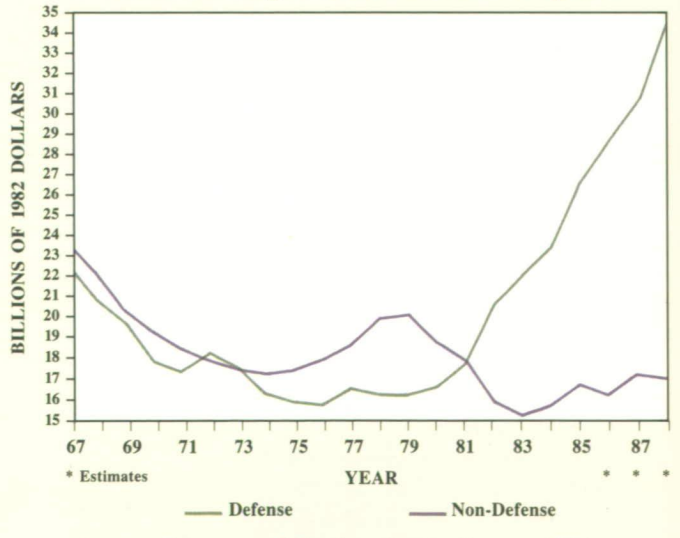
Source: Science and Engineering Indicators 1987
Appendix Table 4-1, pages 234-235

Aerospace Balance of Trade vs. Overall U.S. Balance of Trade 1970 – 1986



Source: Aerospace Facts and Figures 1987-88
page 125

Relative Changes in Federal R&D Obligations



Source: Science and Engineering Indicators 1987
Appendix Table 4-37, page 265

Government Civil Space Applications Budgets*

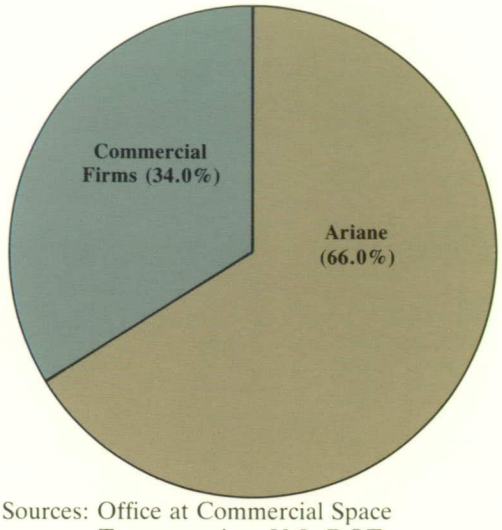
(Approximate: In millions of then year U.S. dollars)

Entity	Satellite Communications		Remote Sensing		Materials Processing	
	1983/84	1987	1983/84	1987	1983/84	1987
ESA	222	249	41	198	75	39
France	52	105	92	120	8	14
West Germany	100	30	5	8	22	32
Japan	73	109	66	99	9	14
Canada	33	36	35	43	N/A**	N/A
TOTAL	480	529	239	468	114	99
U.S.A.	32	100	15	24	22	35

*Data for U.K. and Italy unavailable.
**Not available.

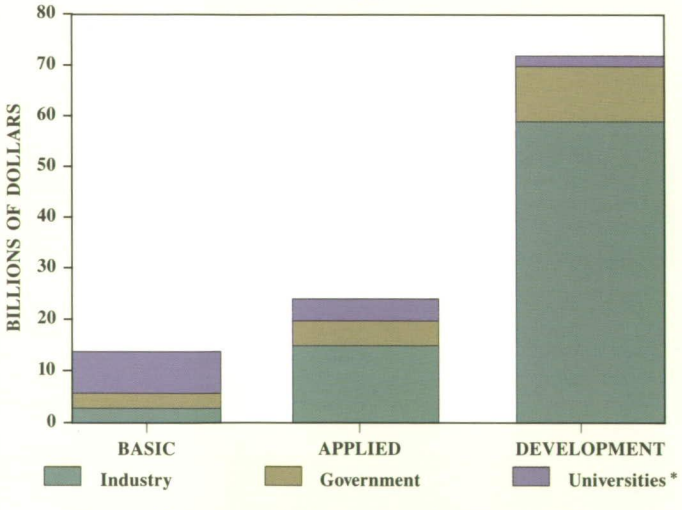
Source: U.S. Civil Space Program: An AIAA Assessment, March 1987, AIAA

Market Share of U.S. Commercial Firms and Ariane Launch Vehicles, 1989 – 1992



Sources: Office at Commercial Space Transportation, U.S. DOT
Arianespace Launch Manifest, 1988

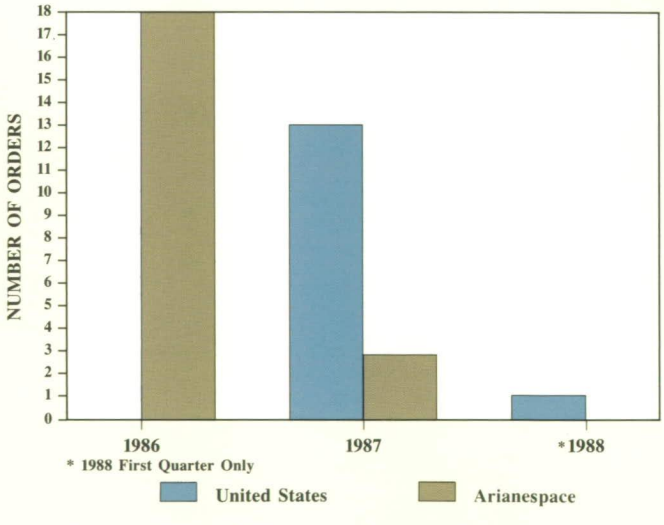
U.S. Basic and Applied R&D by Sector 1985



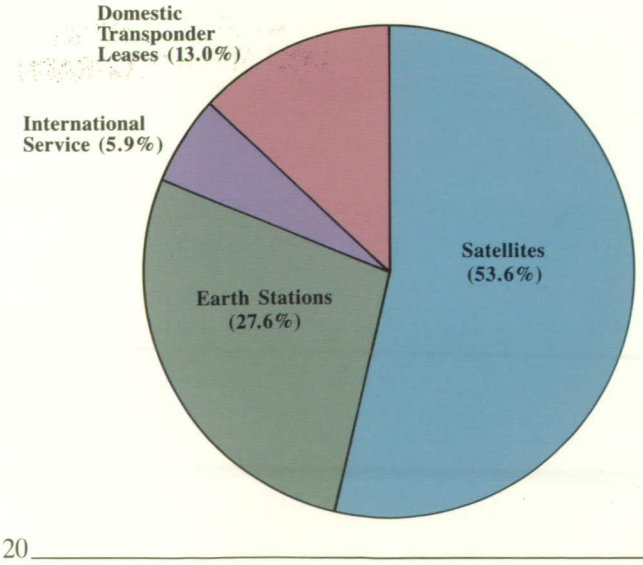
Source: Science and Engineering Indicators 1987
Appendix Table 4-7, page 241

**Universities includes universities, colleges, and non-profit institutions*

Orders Placed for Commercial Launches of Communications Satellites



Source: Office of Commercial Space Transportation, U.S. DOT



Communications Satellite Revenues by Market-1986 (Millions of Dollars)

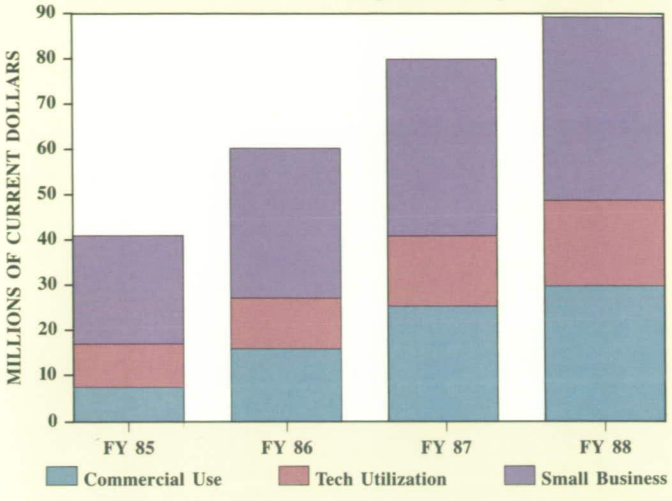
Satellites	1945
Earth Stations	1000
International Service	213
Domestic Transponder	470

Source: Space Market Model, by Dr. Peter Bishop, Director, Space Business Information Center, August 1988

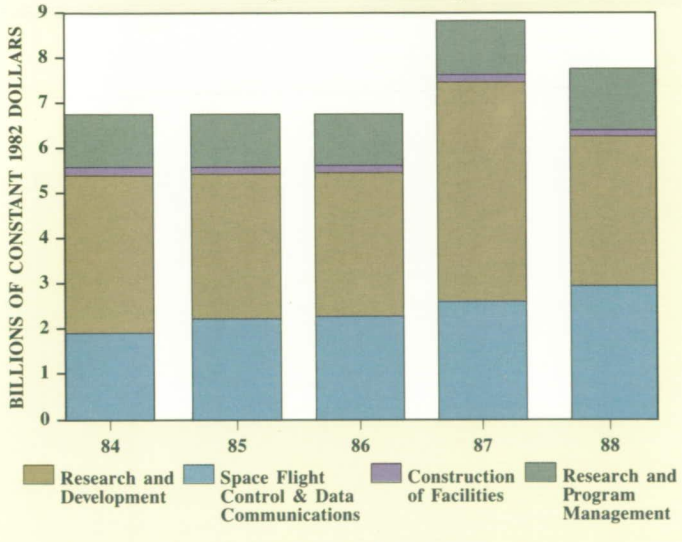
Note: Data is derived from several sources and intended to be used as part of a larger economic model. It may not be exact at the individual level.

Presented in this section is the budget history of the Office of Commercial Programs, and a review of highlights and trends of the overall NASA budget.

Office Commercial Programs Budget History



NASA Budget Breakdown by Function



Source: "The Budget of the United States," in Aerospace Facts and Figures 1987-88, page 71

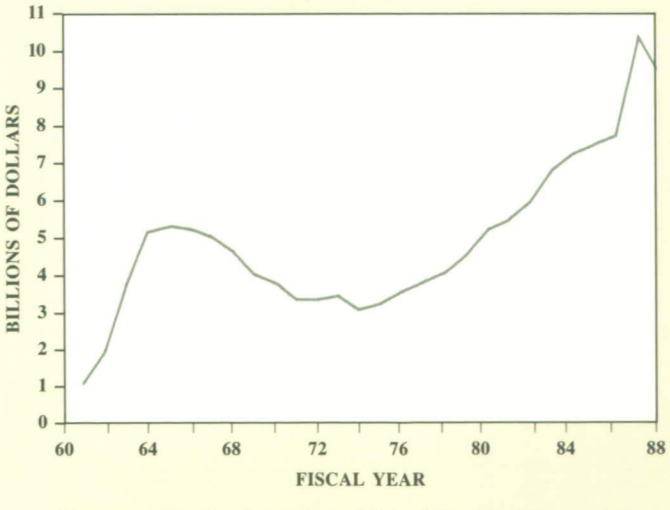
States in which NASA Expenditures Exceed $1 Million

Includes Contracts, Grants and Facilities

	(Dollars)
California	3,204,307,000
Texas	721,517,000
Maryland	709,518,000
Florida	687,722,000
Alabama	649,512,000
Lousiana	331,407,000
Utah	293,751,000
Virginia	284,664,000
New Jersey	228,617,000
Ohio	208,156,000
Connecticut	200,531,000
Washington, DC	167,058,000
Mississippi	100,006,000
Colorado	71,201,000
New York	45,275,000
Massachusetts	40,981,000
Pennsylvania	39,874,000
Georgia	33,323,000
New Mexico	19,899,000
Wisconsin	18,401,000
Arizona	17,386,000
Tennessee	15,011,000
Michigan	9,470,000
Illinois	8,818,000
Indiana	8,626,000
Minnesota	7,595,000
Iowa	6,375,000
N. Carolina	5,439,000
Hawaii	5,355,000
New Hampshire	5,283,000
Washington	4,118,000
Alaska	3,287,000
Oklahoma	2,521,000
Missouri	2,230,000
Kansas	1,589,000
Rhode Island	1,540,000

Source: NASA

NASA Budget in Actual Dollars



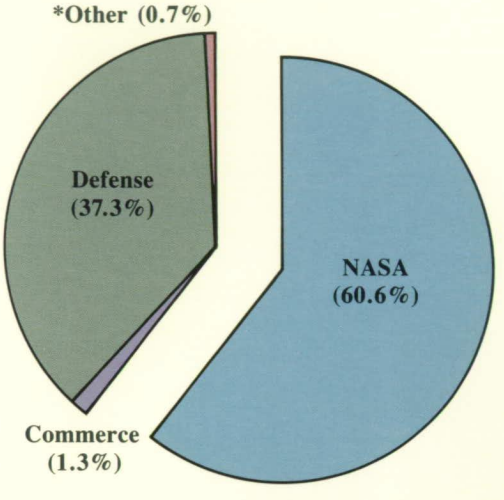
Source: "The Budget of the United States," in Aerospace Facts and Figures 1987-88, pages 70-71

NASA Centers Procurement and Employment-FY86

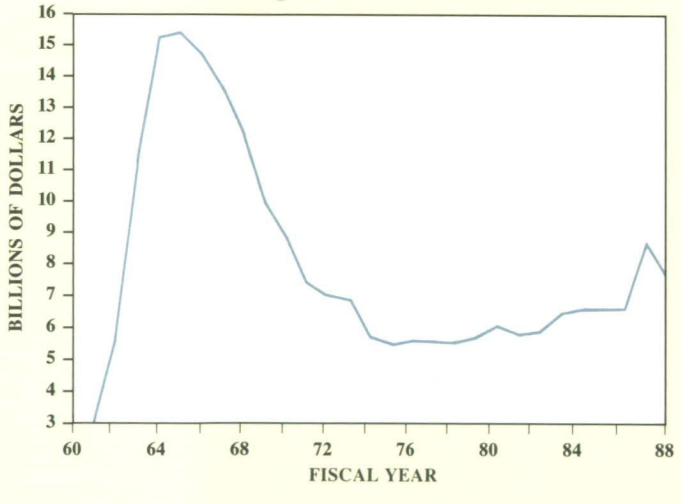
	Procurement (Mil $)	Employment Federal	Support Contractors
MARSHALL	1892	3260	962
JOHNSON	1360	3269	6002
GODDARD	1265	3679	2703
KENNEDY	1027	2051	8759
JPL	895	3723	
LEWIS	625	2598	959
HQDC	435	1362	240
AMES	361	2072	1523
LANGLEY	261	2814	1491
NSTL	57	123	1048

Source: NASA Pocket Statistics 1987

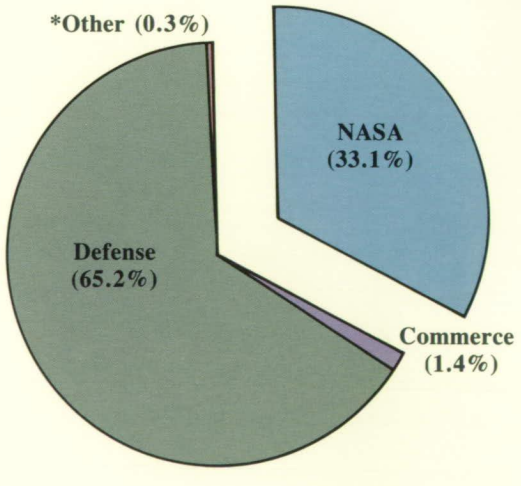
U.S. Space Activities by Department 1976



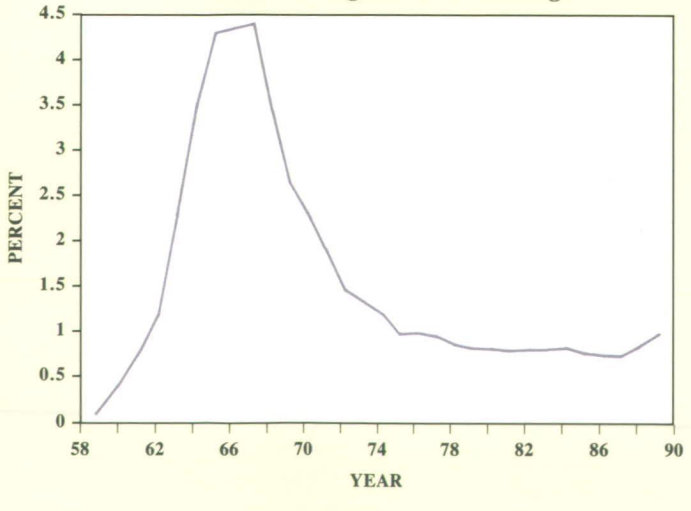
NASA Budget in Constant 1982 Dollars



U.S. Space Activities by Department 1986



NASA Percentage of Federal Budget



Source: Aeronautics and Space Report of the President
Appendix E-1, page 145
**Other includes Agriculture, NSF, Energy, Interior*

James T. Rose	Assistant Administrator
Lawrence F. Herbolsheimer	Deputy Assistant Administrator
J. Michael Smith	Deputy Assistant Administrator (Program Development)
Richard H. Ott	Director, Commercial Development Division
Henry J. Clarks	Director, Technology Utilization Division
Harry W. Johnson	Director, Small Business Innovation Research Division
Dr. Barbara Stone	Director, Plans, Policy & Evaluation Division
Thomas D. Brown	Director, Program Support Division

To ensure diverse, high-level input from U.S. industry and business, NASA has established a committee of senior corporate and university executives to advise the agency in its activities to encourage the commercial development of space.

Formed as a subcommittee of the NASA Advisory Council, the new group will assist NASA by reviewing policies and programs, and recommending strategies to implement the national space policy goals to promote greater investment and participation by the U.S. private sector in America's civil space program.

The Commercial Programs Advisory Committee, which held its first meeting in July and will convene quarterly, is chaired by Mr. Edward Donley, Chairman, Executive Committee, Air Products and Chemicals, Inc. Other members are:

Mr. Robert Anderson
Chairman, Executive Committee
Rockwell International Corporation

Mr. Rand V. Araskog
Chairman and Chief Executive Officer (CEO)
ITT Corporation

Mr. James K. Baker
Chairman and CEO
Arvin Industries, Inc.

Mr. Paul Bancroft, III
Retired President and CEO
Bessemer Securities Corporation

Dr. Thomas A. Bartlett
Chancellor
The University of Alabama System

Mr. Robert K. Campbell
Chairman, President and CEO
Pennsylvania Power & Light Co.

Mr. John L. Clendenin
Chairman and CEO
Bell South Corporation

Mr. Peter M. Flanigan
Managing Director
Dillon, Read and Company, Inc.

Mr. Fred L. Hartley
Chairman and CEO
Unocal Corporation

Mr. Larry D. Horner
Chairman and CEO
Peat Marwick Main & Co.

Mr. Charels E. Hugel
President and CEO
Combustion Engineering, Inc.

Dr. H. Bryce Jordon
President
Pennsylvania State University

Mr. Lewis W. Lehr
Retired Chairman and CEO
3M

Mr. John C. Rennie
President
Pacer Systems, Inc.

Dr. Roland Schmitt
President
Rensselaer Polytechnic Institute

Mr. David W. Thompson
President and CEO
Orbital Sciences Corporation

Dr. Joe B. Wyatt
Chancellor
Vanderbilt University

NASA