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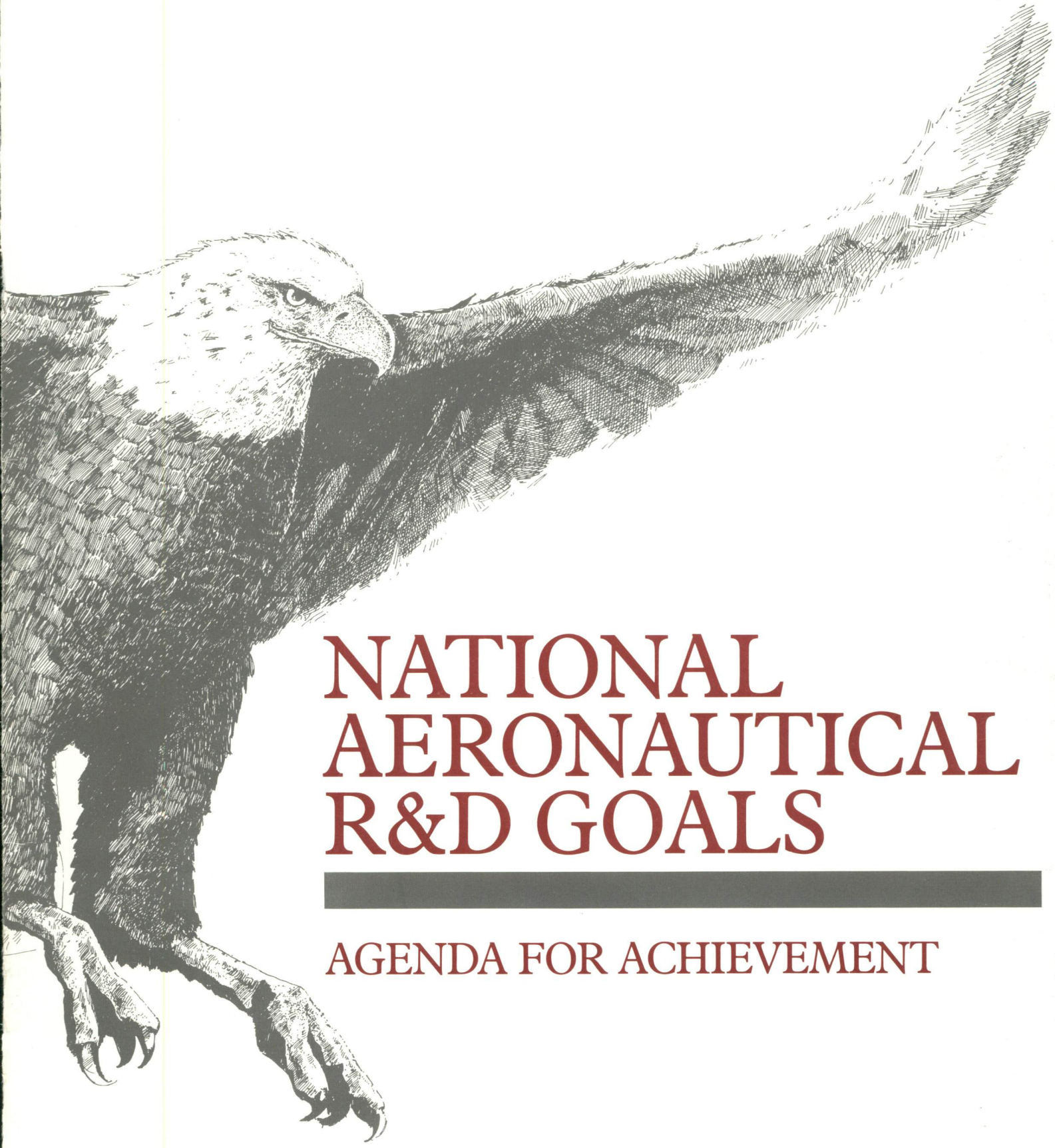
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NATIONAL AERONAUTICAL R&D GOALS

AGENDA FOR ACHIEVEMENT

Executive Office of the President
Office of Science and Technology Policy

ACTION PLAN SUMMARY

The Committee believes that now is the time for the United States to organize a long-term, aggressive, and positive thrust to remain competitive in the world aeronautics marketplace and secure in our national defense. The new era of global competition and the constrained United States fiscal environment pose a national challenge for sustained U.S. leadership. The agenda for achievement of the National Aeronautical R&D Goals will require concerted effort by the Federal Government, industry, and the nation's universities. Specific recommendations for action are:

1. **Increase innovative industry R&D efforts given the certainty of intensifying global competition and the importance of new technology for U.S. competitiveness.**

2. **Aggressively pursue the National Aero-Space Plane program, assuring maturation of critical technologies leading to an experimental airplane.**

3. **Develop fundamental technology, design, and business foundation for a long-range, supersonic transport in preparation for a potential U.S. industry initiative.**

4. **Expand domestic research and development collaboration by creating an environment that reflects the new era of global competition.**

5. **Encourage government aeronautical research in long-term emerging technology areas which promise high payoffs.**

6. **Strengthen American universities for basic research and science education through enhanced government and aerospace industry support and cooperation.**

7. **Improve the development and integration of advanced design, processing, and computer-integrated manufacturing technologies to transform emerging R&D results into affordable U.S. products.**

8. **Enhance the safety and capacity of the National Airspace System through advanced automation and electronics technology and new vehicle concepts, including vertical and short takeoff and landing aircraft.**

FOREWORD

Almost two years ago, the Aeronautical Policy Review Committee—composed of sixteen leaders of government, industry, and universities—considered the evolving international scene in aeronautics and America's future in it. In their March 1985 report, "NATIONAL AERONAUTICAL R&D GOALS: TECHNOLOGY FOR AMERICA'S FUTURE," the Committee recommended that all sectors of American aeronautics direct their skills and energies toward the highest-payoff technology areas to sustain the nation's leadership position.

Toward that end, three specific goals—in subsonic, supersonic and transatmospheric flight regimes—were established. In the intervening time, these goals have been accepted by the American aviation community as the centerpiece of national aeronautics strategy, and have attracted global attention. Action on all three goals is in progress.

However, the Committee believes that the depth of foreign aeronautical resolve and the concerted national effort required to preserve American competitiveness are still largely underestimated. Sustained U.S. leadership will require greater achievement by all sectors—government, industry, and academia. Both the opportunity and challenge are unprecedented. Accordingly, the Committee believes that this challenge to our competitiveness is so important—not just to the nation's diverse aeronautics industry, but to the nation as a whole—that it now issues this call to action. This sequel presents a cohesive U.S. strategy and an eight-point action plan to achieve the National Goals and remain a viable competitor in the world aviation marketplace.



William R. Graham
Science Advisor to the President and
Director, Office of Science and Technology Policy

February 1987

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"The depth of foreign aeronautical resolve and the concerted national effort required to preserve American competitiveness are still largely underestimated."

U.S. AERONAUTICS: A CHANGING PERSPECTIVE

The Challenge

Innovation in science and technology has been the driving force for American growth and power since World War II. It has given us military strength, a high standard of living, and—until recently—a broad range of superior products which dominated world trade.

That picture has changed dramatically over the past decade. We are challenged by a new global economy with technologically equal, well-organized competitors actively backed by foreign governments. European and Pacific Rim nations recognize that science and technology hold the key to their future economic and military well-being, and they are expanding investments in upgrading their capabilities.

"The aeronautics industry has long held a unique position in its contribution to trade and to national security, and as a symbol of U.S. technological power."

Instead of trade surpluses, the United States has huge trade deficits. Most Americans are awakening to the serious dangers in this decline, notably in steel, automobiles, and electronics. The trade deficit has meant slowed economic growth, business failures, and permanent loss of millions of jobs.

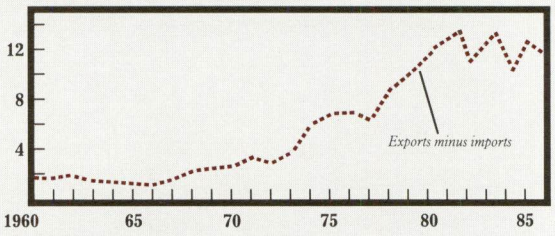
Even in high technology, the United States has steadily lost market share since 1980. In 1986, for the first time, high-technology imports exceeded exports. These losses can do enormous damage to our future competitiveness and national security. We must never again take our economic superiority for granted.

On balance, the United States is still the world leader in aviation. The aeronautics industry has long held a unique position in its contribution to trade and to national security, and as a symbol of U.S. technological power. Aircraft incorporate many advanced technologies and stimulate the development of high technology on a broad front.

Aerospace trade surplus of $11.8 billion in 1986, the highest of all U.S. export sectors, contrasts to the trade deficit in manufactured goods of $136 billion. Aircraft and parts comprise over 90 percent of this surplus. These export sales are vital to amortize huge R&D expenditures and to achieve economies of scale. Aerospace total shipments exceeded $96 billion in 1986.

Aerospace Balance of Trade

Billions of Current Dollars



Source: U.S. Department of Commerce

But that industry today faces profound changes: formidable competition for international and domestic sales, challenges to military superiority requiring technically sophisticated yet more affordable weapons systems, and limitations of capital and skilled workers. The implications are unsettling.

Aeronautics has played a crucial role in national security for more than 40 years. With major R&D investments in advanced technology aircraft, aviation will continue to fulfill a major defense role. Though requirements for civil and military aircraft differ, much of the technology base, the production base which is centered in 15,000 company suppliers supporting the major aircraft manufacturers, and many of the skills and processes used are common. A weakening of the civil industry will ultimately result in more expensive military systems, and the reverse is true as well.

Significant sustained foreign competition exists in all three National Goal areas: subsonics, supersonics, and transatmospherics. In fact, other nations now dominate the world general-aviation and commuter-aircraft markets, account for nearly half the world sales of rotorcraft, and are achieving significant market penetration in the large commercial transport market. The R&D endeavor of the Soviet Union is the largest in the world, and aggressive Soviet aeronautical R&D constantly threatens the U.S. technological margin. Though America is today's world aviation leader, where will we be tomorrow?

The Opportunity For Leadership

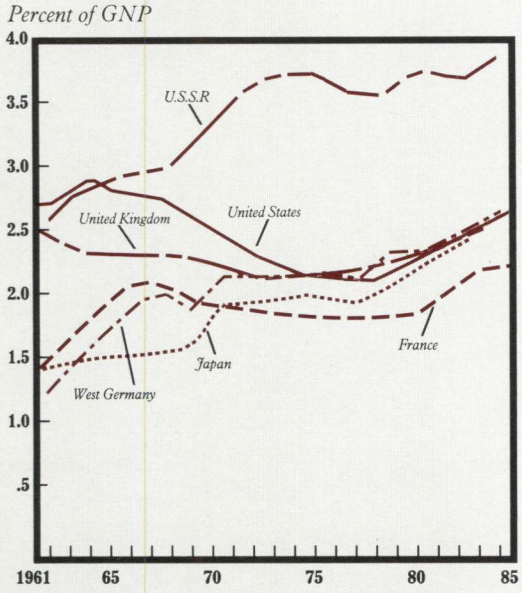
Bold new technological thrusts are essential to preserve U.S. aeronautical superiority in the world marketplace and enhance global security through the excellence of our military aircraft.

The National Goals for Aeronautical R&D outline numerous opportunities for dramatic advances in technology that could reshape aviation by the turn of the century. Achievement of these goals will lead to entirely new types of aircraft with vastly superior capabilities. Gains of this order will mean major benefits to our national economy and security, but only if we are the first to exploit them. These opportunities are an equally powerful driving force for foreign competitors.

The constrained U.S. fiscal environment, a continuing and difficult problem, requires a cohesive national strategy and a new sense of collective responsibility for achieving the National Goals. This will challenge the resourcefulness and creativity of

the Federal Government, of industry, and of the nation's universities. With their effective cooperation, we must cut the cost of technological advancement and increase the speed at which new aeronautical technologies translate into products and processes. The changes may involve altering traditional approaches. But America holds the key for responding to the challenge: a genius for innovation and a solid foundation in research and development.

National Expenditures for R&D



Source: National Science Foundation Science Indicators—1985

Most important, to preserve America's aeronautical leadership we must accord a higher national priority to research and development. R&D is the highest leverage for revitalization of American economic and strategic competitiveness. These R&D expenditures must be viewed as long-term investments in the nation's productive capacity, and should weigh heavily in government and boardroom decisions even when resources are tight. Underinvestment in R&D and facilities during the 1960's and 1970's has contributed heavily to the current loss of competitiveness in many other U.S. industries.

Greater attention must also be focused on the availability and quality of scientific and engineering manpower. Similarly, higher education must be strengthened. The universities are vital, for both new knowledge and trained minds. Disturbing signs, however, suggest that university research capacity is deteriorating.

Stronger cooperation between government and industry within a free market framework will strengthen American competitiveness. Working together, each must fulfil the role for which it is best suited.

Industry must recognize the certainty of intensifying global competition. It must continue to expand its R&D investment while establishing a more risk-taking approach to world leadership in the commercialization of product and process technology. A strong and healthy Independent Research and Development (IR&D) program, which is the source of much of the innovative work in the industry, is essential in expanding the nation's technology base and strengthening American leadership.

Government, for its part, can best support long-term, high-risk, high-payoff research. Rapid and effective transfer of this technology to the private sector is essential in capitalizing on these results for U.S. competitive advantage. Government must also create a policy environment which fosters U.S. competitiveness.

"The constrained U.S. fiscal environment requires a cohesive national strategy and a new sense of collective responsibility. . ."

The National Aeronautics and Space Administration (NASA) is this country's focal point for aeronautical research and technology and national aeronautical facilities. NASA must strengthen its capabilities and take a more assertive leadership role in coordinating and facilitating long-term U.S. research efforts for maximum effectiveness. The health and productivity of our national facilities are fundamental to meeting the country's growing R&D requirements.

America has to compete in the international arena, but it also has to cooperate. To enjoy a high standard of living we need trading partners with healthy economies. The growing trend toward internationalization of aircraft manufacture will require learning how to work effectively with foreign partners while preserving technological leadership. This leadership need not be threatened if we maintain a vigorous program of basic research and technology development. However, the U.S. government and aeronautical firms must pursue equitable arrangements when actual or potential competitors seek to obtain our skills and technical knowledge.

"To preserve America's aeronautical leadership we must accord a higher national priority to research and development."

The Committee clearly recognizes that progress on many other issues such as the federal budget deficit, trade and tax policies, and exchange rates are essential to sustained improvements in America's competitive position. But in formulating an implementation strategy for the National Aeronautical R&D Goals, the Committee focused on R&D-related issues. The following pages detail specific recommendations for action.

NATIONAL AERONAUTICAL R&D GOALS: FRAMEWORK FOR ACTION

SUBSONICS GOAL: A NEW GENERATION OF SUPERIOR U.S. AIRCRAFT

Subsonic aircraft dominate the world market, exceeding $35 billion annual sales by U.S. manufacturers alone, and are expected to remain the largest aerospace market into the next century. They include all commercial transport categories, from general aviation and commuter aircraft to intercontinental transports; all military airlifters; and a large array of helicopters and emerging high-speed rotorcraft.

Commercial subsonic aircraft rank first among U.S. manufacturing exports, with a $9.6 billion average trade surplus over the past five years. The immense subsonic market is the foundation for sustaining the major U.S. airframe manufacturers and their 15,000-company suppliers, who support both civil and military needs. American preeminence in this market will be critical to generate capital for investments in modern manufacturing and to exploit opportunities in supersonic and transatmospheric flight. It is in this pivotal worldwide market that foreign competition is having the most impact.

This first National Goal envisions an entirely new generation of fuel-efficient U.S. aircraft operating in a flexible and modernized National Airspace System. Its aim is a safe, congestion-free interstate system, offering superior air transportation at reduced cost. The subsonics goal also envisions the development of advanced military airlift capabilities, tankers, long-endurance aircraft, rotorcraft and other spin-off military requirements. Recent declines in fuel prices have heightened the importance of aircraft affordability. Even with rising fuel prices, cost of ownership, including acquisition, will dominate the economics of the intensely competitive world aircraft markets.

"Key advances in drag reduction, composites, and automation must be readied by the early 1990's."

At present, the subsonic industry is busy with advanced R&D activities for next generation systems. Major aircraft and engine manufacturers are accelerating technology readiness for application to new aircraft carrying some 150 passengers for the early 1990's. These aircraft will incorporate revolutionary superbypass engines with 30% better fuel consumption. Flight tests of some of these advanced propulsion systems are already under way.

A new military transport for the early 1990's, the C-17, is also ongoing. This and other developments of advanced military aircraft will have an important impact on gas turbine engines, composite structures, microelectronics, and fiber-optics technology, and will contribute to future cost superiority.

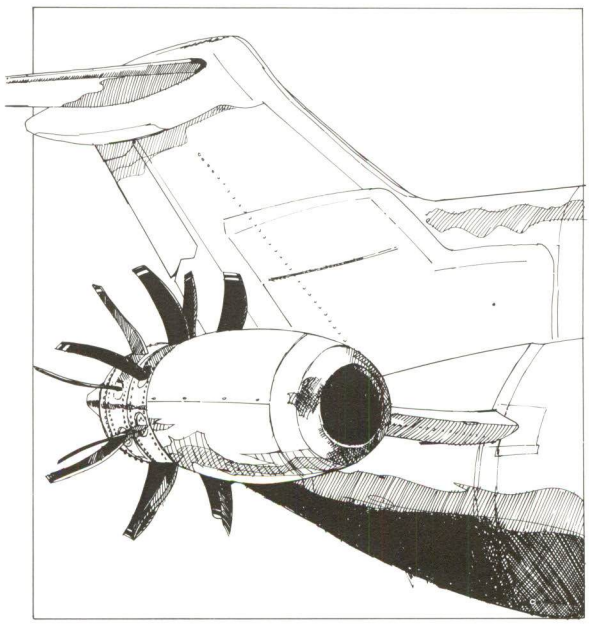
The Department of Defense (DOD), NASA, and the rotorcraft industry are making substantial investments in revolutionary, high-speed automated rotorcraft now finding their way into military systems. These include the tilt rotor, which combines the advantages of a helicopter and a turboprop. Another is the X-wing, whose X-shaped rotors lift the craft on takeoff and serve as wings in forward flight.

Civil derivatives of some of these high-speed rotorcraft, operating in the vertical or short takeoff modes, are foreseen with the economy, productivity, and maintainability of fixed-wing passenger aircraft. Advanced craft of this kind can provide improved inter-city and inter-region transportation, reducing congestion in U.S. airports without major investments in new runways.

Key advances in drag reduction, composites, and automation must be readied by the early 1990's. Several exciting laminar-flow concepts, that greatly reduce drag by smoothing air flow over wing surfaces, have been successfully tested in NASA wind tunnels and in small-scale flight experiments. However, large-scale flight experiments under realistic conditions and operating environments are needed before introduction in new transport aircraft.

New composite materials offer greater toughness and processability, and a 30-40% potential reduction in structural weight. However, we lack a comprehensive body of knowledge on how these materials will behave in highly loaded structures and in long-term operation. As new materials emerge from the laboratories, significant investment for validation is essential. This endeavor would clearly benefit from joint NASA, DOD, Federal Aviation Administration (FAA), and industry cooperation.

Today's frequent and costly delays at metropolitan airports will become worse with the projected



growth in aviation. Aggressive pursuit of automation, artificial intelligence, and electronic advances for both aircraft and the National Airspace System are vital. Full realization of the National Goals will depend on how fast the National Airspace System can incorporate these advances and accommodate new vehicle capabilities such as tiltrotor, V/STOL, supersonic, and hypersonic aircraft.

Technology validation is currently the weak link in the R&D chain. Validation enables designers to incorporate new advances into a product with confidence in its performance, integrity, and cer-



tificability. It is the longest and most expensive stage in advancing new technology. It is also the point where U.S. R&D momentum has become most vulnerable. Joint industry, NASA, and DOD programs have traditionally played an important role in this area. In this constrained fiscal environment, greater industry mobilization as well as enhanced industry-government cooperation in the subsonic arena is vital. The aviation industry has recently accelerated technology readiness for product application early in the 1990's. This trend must continue if the U.S. is to maintain its competitive momentum into the next century.

NASA should focus primarily on long-term fundamental research. Difficult and demanding decisions must continue to emphasize emerging technology areas that promise major improvements in future aircraft. NASA must also strengthen its capabilities and exert stronger leadership in national research efforts and rapidly disseminate information to U.S. industry. While the potential advancements in range and payload made possible by development of key technologies will have significant benefit to growing military requirements for global operations, the DOD is appropriately channeling much of its current subsonic R&D into more specialized stealth, rotorcraft and cruise missile technology.

Clearly, the nation needs to establish a collective commitment among industry, DOD, NASA, FAA, the universities, and Congress to assure American leadership in this pivotal subsonic area. The huge market can provide the resources for private-sector investment in technology and manufacturing innovation for all three goals. We are approaching an important crossroad: one path leading to steady erosion of U.S. participation in world markets; the other to economic growth, and job creation. Industry creativity, leadership, and resolve will be the decisive factors.

SUPERSONICS GOAL: LONG-DISTANCE EFFICIENCY AND ENVIRONMENTAL COMPATIBILITY

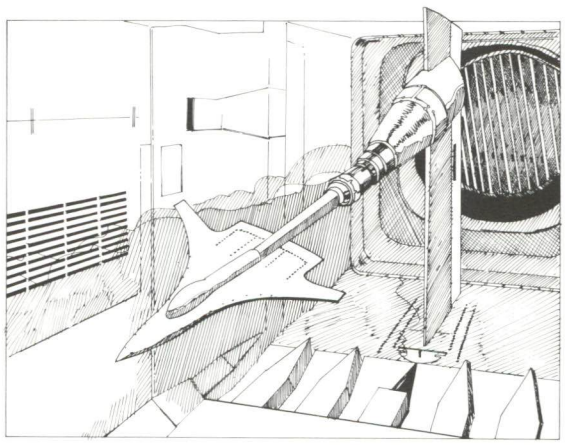
This national goal is a great market-driven opportunity. Trends into the next century almost certainly will brighten the outlook for long-range, high-speed transportation.

One trend is rapid growth of world population. More than 75% of this growth will be in distant developing nations. Another trend sees the axis of global economy and technology shifting farther and farther to East Asia and the Pacific Basin. Mutual security bonds are of increasing importance in this region in light of a potential Soviet buildup.

"We are approaching an important crossroad . . . creativity, leadership, and resolve will be the decisive factors."

Yet, U.S. access to the vast Pacific area is constrained by distance. With subsonic planes, travel time between these countries and their major trading partners in the United States and Europe is from 12 to 18 hours. As travel and trade increase, demand is mounting for more productive forms of air travel. Substantial reduction of flying time means great reduction in human fatigue and improved effectiveness at the destination.

Supersonic cruise technology has important application to future combat aircraft as well as to transports. Efficient supersonic cruise, coupled with high maneuver capability, would mean considerable increase in military aircraft effectiveness and survivability. Even though military forerunners are often essential to advanced commercial undertakings, future military requirements will differ significantly from a commercial supersonic transport. Economic and performance considerations, operational requirements such as



airport and community noise levels and sonic boom restrictions, as well as stringent operational life, reliability and safety requirements are vital differences. However, recent military developments have resulted in advances in propulsion, materials and systems which will benefit advanced supersonic transports.

"By the early 1990's, the U.S. industry could begin design and development, culminating in a new supersonic transport certification around the year 2000."

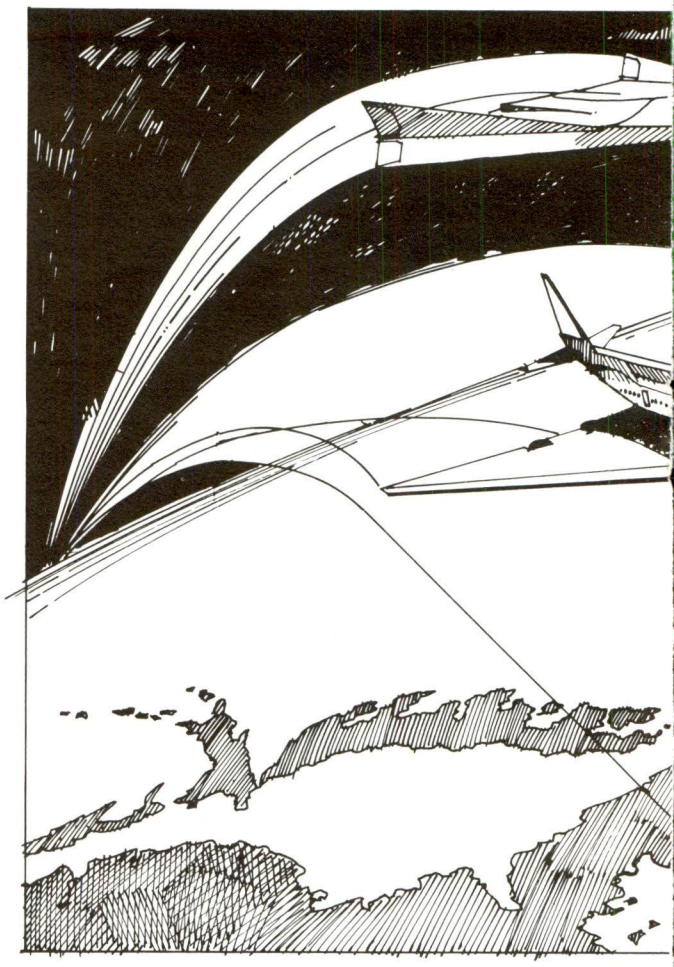
The U.S. aeronautics industry must strive to be the leader of the advanced high-speed transport enterprise. It should identify the most promising concepts and the necessary technology for economic competitiveness, safety, and environmental compatibility at reasonable business risk. Decisions must be based on a full understanding of the potential market, economics, environmental implications, the future navigation and air traffic control system, and a wide range of design options such as flight speeds and fuel types. For the airlines, the bottom line for any high-speed transport will be economic performance—competitive earnings capability and operating costs compared with long-range subsonic jets.

As the timing and need for high-speed transport come into better focus, the industry must begin to explore creative ways to assemble the required know-how and capital resources. Because of the risks and the extremely heavy funding, a high-speed transport is probably beyond the capabilities of a single U.S. aircraft or engine company. It may require pooled resources, or perhaps an international consortium. If any arbitrary governmental impediments to such development and production collaboration by major commercial competitors are encountered, they should be identified and eliminated.

On the engineering side, key technologies for advancing supersonic cruise capability have not been aggressively pursued by the U.S. since the 1971 termination of the U.S. Supersonic Transport program. However, the NASA-funded Supersonic Cruise Research program, which ended in 1981, established a constructive base for further advancement. Operational experience with the Concorde and SR-71 also provides a stepping stone for a second-generation supersonic transport.

If the U.S. is to take the lead, a coordinated and disciplined approach by industry and government is necessary. NASA and industry must hasten the development of promising technologies such as supersonic laminar flow, thermoplastics, metal matrix composites, and supersonic through-flow and variable-cycle engine technology. Airport and community noise standards present difficult challenges, but solutions can be found through technology, design and flight management. Further research is urgently needed on the generation, propagation and public perception of low-level sonic booms. The FAA and our air traffic management and control capabilities must keep pace so that new aircraft can be certified in a timely manner and operated efficiently within the National Airspace System.

Without question an economically viable and environmentally compatible supersonic transport, which would cut flying times to the Pacific Rim by 70 to 80 percent, could be available by the late 1990's or early next century. This holds tremendous potential for the American aviation industry, the world airlines, and the traveling public. It will create a multi-billion dollar market for its participants, not only in the Pacific but by potentially capturing a majority of all long-range intercontinental markets. An efficient supersonic transport represents a logical and essential link between the subsonics of this century and the hypersonics of the next.



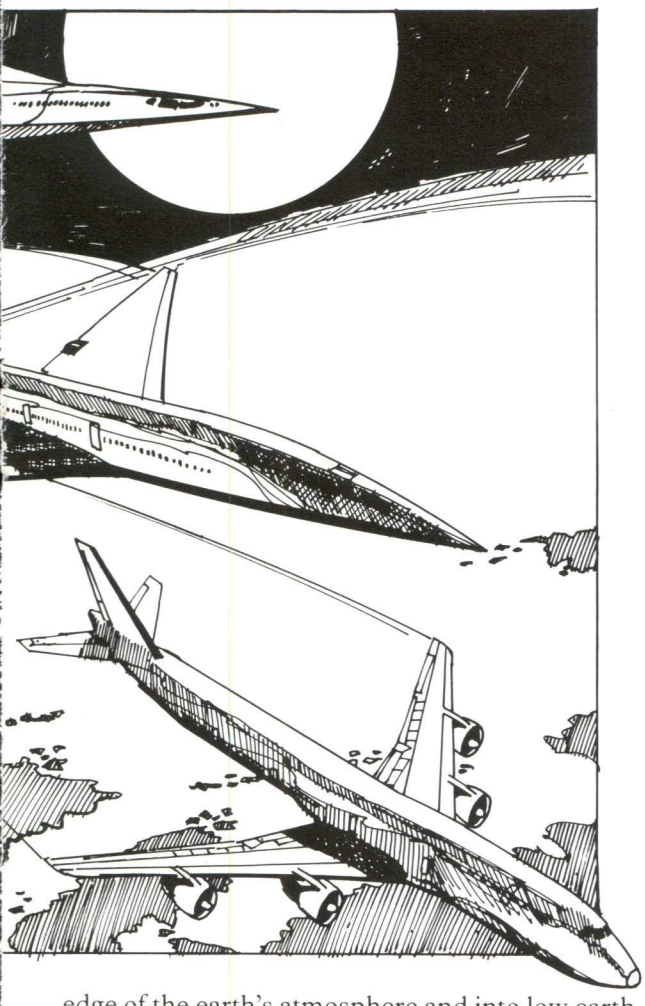
The latest Airbus models from Europe are a constant reminder that we have no corner on using advanced technology in competitive aircraft. Japan and European nations are keenly interested and can be expected to expand their R&D investments in this area. Aeronautics remains a dynamic, competitive industry in which those who choose to stand still are quickly left behind.

America's first step should be a focused and coordinated basic technology development effort by NASA, industry, and academia including comprehensive preliminary design studies. By the early 1990's, the U.S. industry could begin design and development, culminating in a new commercial supersonic transport certification around the turn of the century.

TRANSATMOSPHERICS GOAL: TO SECURE FUTURE OPTIONS

Significant progress since the announcement of this goal has brought both its impressive opportunities and its challenges into sharper focus.

By the turn of the century an air-breathing vehicle could take off from an airport runway and fly between 5 and 25 times the speed of sound to the



edge of the earth's atmosphere and into low earth orbit. The plane would return to a conventional runway. Such a new class of aerospace vehicle is foreshadowed by recent technical advances. It would save much weight and cost by using oxygen in the air instead of carrying very large quantities of liquid oxygen as in rocket systems.

A decision to go forward with research on an aerospace plane was announced by President Reagan in his State of the Union address on February 4, 1986. The National Aero-Space Plane program, a bold new technology initiative to carry out the decision, is being conducted jointly by DOD and NASA. These agencies have already stimulated a major expansion of research in all the technologies key to hypersonic and transatmospheric flight. Such rapid mobilization of this degree in both government and industry is unprecedented in recent times. This initiative has reversed more than a decade-long decline in the U.S. hypersonics expertise and technology base in industry and the university community.

The National Aero-Space Plane program is accelerating effort on critical technologies: air-breathing propulsion which must function efficiently from takeoff to near orbital velocities; high-temperature, lightweight materials, and thermal structures that can withstand exposure to extreme heat during ascent and descent or during sustained hypersonic flight in the atmosphere; and new computational tools for analysis of the highly interdependent airframe and propulsion systems. We have the capability to integrate these technologies in the experimental X-30, which should begin validation in actual flight by the early 1990's.

The usefulness of this project is hard to exaggerate. The U.S. military, increasingly dependent on space for communications, intelligence, and early warning, urgently requires such a space vehicle. Transatmospheric craft could place military and civil payloads into orbit and service them more quickly, reliably, and inexpensively than the current Space Shuttle or expendable launch vehicles. Need for massive, fixed launch facilities at a few vulnerable sites would be eliminated. Flexible, fast-turnaround transatmospheric vehicles might cut the cost of delivering payloads into orbit by an order of magnitude.

The extreme altitude and speed capability would make our military aircraft far less vulnerable. Ability to fly to orbit on very short notice while operating from conventional runways would give the advantage of surprise. Flights on unpredicted courses could observe secret installations and activities before they could be hidden. A versatile transatmospheric vehicle could react quickly to any point on the globe in approximately 90 minutes.

A commercial transport derived from this technology could be considered following flight testing of the X-30 research airplane and operational experience with hypersonic military aircraft or space transportation vehicles. It could fly at altitudes of 20 miles or higher and at five times the speed of sound or greater. Travelers would reach most distant destinations within two hours. A hypersonic transport, a major step beyond a supersonic transport, might prove an attractive option for the long-distance market in the next century. The very significant economic, environmental, safety and operational challenges of a public hypersonic transport necessitate extensive research and technology development to exploit the civil transportation potential of hypersonic flight.

"The X-30 experimental airplane should begin technology validation in actual flight by the early 1990's."

As the United States vigorously pursues space transportation systems, foreign nations are not blind to their potential. They, too, are aggressively working on a broad range of reusable spacecraft. These include the French Hermes space transportation system, advanced horizontal takeoff systems such as the British HOTOL and German Sanger vehicles, and the aerospace plane concepts being actively studied in Japan. The Soviets, who already have more responsive space launch capabilities with an annual launch rate many times greater than ours, are well into developments, some of which are beyond anything we have in either operation or design.

Accordingly, the Committee strongly endorses the National Aero-Space Plane initiative in a broad U.S. and global competitive context involving both aerospace leadership and national security.

THE AGENDA FOR ACHIEVEMENT

Clearly, now is the time for the United States to organize a long-term, aggressive, and positive thrust to remain competitive in the world aviation marketplace and secure in our national defense. As the leader of the free world, the United States cannot retreat behind protectionist barriers in the face of formidable economic competitors or military adversaries. America has lost momentum but not its basic capability. In aeronautics, the expertise represented by the government, industry, and university partnership that has evolved since the founding of the National Advisory Committee for Aeronautics in 1915 is unsurpassed anywhere. The most decisive factor in America's favor is the pace of innovation itself.

"The United States cannot retreat behind protectionist barriers. . ."

The current environment with its resource limitations poses a national challenge to our creativity and resolve to make the difficult choices and necessary commitments for U.S. preeminence. The agenda will require concerted effort and greater achievement by the Federal Government, industry, and the nation's universities. The Committee recommends an eight-point action plan to strengthen U.S. competitiveness in the worldwide aerospace marketplace and strategic arenas.

ACTION PLAN

1 Increase innovative industry R&D efforts given the certainty of intensifying global competition and the importance of new technology for U.S. competitiveness.

The U.S. is challenged by a new global economy. America's ability to compete depends heavily on greater mobilization and commitment of the major aircraft manufacturers and their suppliers. Affordability and quality will be pivotal to the success or failure of U.S. entries in the world markets. With so much of our competitive position dependent on new technology, the Committee recommends that:

- U.S. aeronautics industry continue to expand its own investments in R&D.
- American industry stress affordability and quality during product design, a longer-term perspective in business strategies, and a more risk-taking approach to strengthen American leadership in light of the escalating global competition.
- Government continue to support a healthy Independent Research And Development (IR&D) program as a sound and proven way of stimulating innovative industrial R&D.

2 Aggressively pursue the National Aero-Space Plane program, assuring maturation of critical technologies leading to an experimental airplane.

The Committee strongly endorses the National Aero-Space Plane program. In pursuing this challenging initiative, government and industry partners should strive to:

- Strengthen preliminary design efforts so that attractive vehicle concepts and key technologies can be identified, shaped, and assigned priorities.
- Assure timely development and maturation of the X-30 focused technologies critical to success of the National Aero-Space Plane program.
- Conduct application studies for future operational vehicles of various sizes and missions to provide a comparative assessment with competitive alternatives.
- Assure broadest U.S. technical community involvement consistent with the need to protect certain sensitive information for national security and U.S. competitiveness.
- Broaden the technology base to enable development of a wide range of U.S. hypersonic cruise vehicles.
- Rebuild university expertise base in hypersonics and transatmospherics research.

3 Develop fundamental technology, design, and business foundation for a long-range, supersonic transport in preparation for a potential U.S. industry initiative.

The National Goal for long-distance supersonic efficiency remains a great market-driven opportunity. Second-generation commercial transports which would cut flying times to the Pacific Basin by 70 to 80 percent are possible by the turn of the century. A coordinated and disciplined approach by government and industry is necessary to develop the technology and to mobilize the large capital resources for full-scale development. The Committee recommends that:

- Industry analyze the market needs for an advanced high-speed transport and identify the economic, speed, size, range, and fuel characteristics necessary to become a successful element in international air transportation. Government and industry determine the necessary characteristics for environmental compatibility.

■ Industry and NASA determine the most attractive technical concepts and the necessary technology developments for future long-range, high-speed civil transports.

■ NASA, industry and academia begin a focused and coordinated approach to ready required technology for U.S. industry development and application.

■ Industry provide strong, creative leadership. A high-speed transport will probably require pooled resources of a number of companies, perhaps an international consortium. Arbitrary governmental impediments to collaboration in design, development, and production by major U.S. commercial competitors should be identified and eliminated.

■ The U.S. aeronautics community explore the development and application of new supersonic cruise technologies to advanced technology military aircraft.

4 Expand domestic research and development collaboration by creating an environment that reflects the new era of global competition.

American companies will have to depend more on themselves and on one another, if they are to stay competitive internationally. Because of changes in the worldwide commercial markets and dramatically rising research and development costs, many U.S. aerospace manufacturers have entered into cooperative relationships with foreign companies to gain market share and reduce financial risk. Collaboration among foreign companies, enabled by less restrictive legal environments overseas, is an increasingly powerful competitive force on the international scene.

Much of the research and development envisioned in this report could benefit from several American firms working collaboratively—sharing the risk while pooling capital, technology, and skilled personnel. The purpose is not to stifle U.S. competition but to enhance international competitiveness. Increased cooperation between federal laboratories and the private sector is also essential. Accordingly, the Committee recommends that:

■ The U.S. aeronautics industry consider the advantages of teaming and other collaborative opportunities now permitted by U.S. law. Research cooperatives that are created by private initiative such as the Microelectronics and Computer Technology Corporation might serve as a model. Associations such as the Aerospace Industries Association are beginning to act as a catalyst.

■ The Federal Government not impose barriers to discussions and teaming between major U.S. Aerospace competitors for development and production projects as well as research. Such teaming is already commonplace in major military aviation procurements. This is particularly important for a commercial supersonic transport, since the magnitude and complexity of the required R&D efforts will probably require collaboration of a number of companies.

■ The U.S. increase rate of technology transfer of government funded R&D to the American private sector for commercial development. Rapid transfer and development are essential in preventing significant loss of that technology to foreign companies. Federal agencies must balance the early open publication of research results with need for early domestic technology transfer. Important new discoveries should receive proper intellectual property protection and early domestic dissemination.

■ Industry and the national laboratories expand cooperative research, technology development, and licensing arrangements under the terms of the Federal Technology Transfer Act of 1986. This Act offers a variety of new incentives and mechanisms for cooperation and rapid transfer of government-sponsored technology to the private sector. Government and industry should identify those areas where U.S. industry might be interested in sharing the costs—and benefits—of technology development.

5 Encourage government aeronautical research in long-term emerging technology areas which promise high payoffs.

Advances in composite materials, propulsion, numerical simulation, and laminar flow will have a profound effect on future vehicles in all three goal areas. NASA provides a unique, central technological resource for this nation's aeronautical preeminence and should now strengthen its capabilities and take a more assertive leadership role in developing the fundamental knowledge base in these emerging areas. Government must also assure the health and availability of critical national facilities to meet the projected increased demands from new aircraft developments across the speed regime.

"A high-speed transport will probably require pooled resources. . ."

Composites

Innovative research could yield high-strength, ultra-lightweight, low-cost composite structures for use in advanced subsonic, supersonic and transatmospheric aircraft. To achieve the full potential of composites, the Committee recommends that:

"NASA should now take a more assertive leadership role in developing the fundamental knowledge base in these emerging areas."

- Government, industry, and the universities intensify development and validation of a comprehensive knowledge base to enable the broad application of composite materials to future aircraft and engine systems.

- NASA and DOD focus research on promising material systems such as thermoplastics and metal matrix composites, and on advanced structural concepts and innovative fabrication techniques to increase damage tolerance and strength and lower cost.

- Civil and military composite development be made a common, mutually supporting national undertaking.

- As new composite materials emerge from the research laboratories, government and industry coordinate national technology validation efforts for large, next-generation primary structures. FAA ensure that appropriate certification standards and rules are developed.

Numerical Simulation

An area of extreme importance for rapid and effective evaluation and optimization of all classes of aircraft and propulsion system designs is numerical simulation, or computer modeling. It is already revolutionizing research in aerodynamics, structures, propulsion, and related areas such as wind shear. The design of highly integrated aerospace vehicles and further improvements in conventional aircraft are dependent on these capabilities. Because these problems involve large numbers of variables, the development of new powerful supercomputers will accelerate progress. To maintain leadership in this vital technology area, the Committee recommends:

- U.S. fully exploit leadership in supercomputer and numerical simulation technology for improved understanding of fundamental physical phenomena and the optimal, cost-effective design of all future aerospace vehicles. This will require more extensive experimental activity to verify numerical simulation results.

- U.S. industry and government accelerate development of parallel processing hardware and software technology and artificial intelligence to significantly increase the fidelity and accuracy of computer simulations.

Propulsion

Ceramic, carbon-carbon, and metal matrix composite materials promise engine operations at extremely high temperatures with improved performance, weight, and life. Successful development of high-temperature materials will spur efficient supersonic cruise propulsion systems and large increases in fighter capability, including short or vertical takeoff and landing aircraft operations. To realize dramatic improvements for subsonic and supersonic propulsion systems, the Committee recommends that:

- NASA and DOD emphasize high-performance propulsion technology with particular focus on high-temperature composite materials.

- NASA and DOD explore advanced propulsion cycles and determine the practicality of the most promising concepts.

- Government and industry develop the fundamental technology base for significant improvements in fuel efficiency, operating life and acoustics of super-bypass subsonic propulsion systems and supersonic variable-cycle engines.

Laminar Flow

Laminar-flow advances offer dramatic improvements in cruise efficiency of both subsonic and supersonic aircraft. Flight testing of small-scale, subsonic laminar-flow concepts has been completed recently. However, important work remains before these concepts can be introduced in large subsonic transports. Little laminar-flow research has been conducted in the supersonic regime. The Committee recommends that:

- NASA develop fundamental laminar-flow technology for supersonic aircraft, with potential to double fuel efficiency and reduce skin surface temperatures. This should include research on high-lift devices or techniques for highly-swept leading edges used during the approach and landing phases of flight.

- NASA and DOD, in conjunction with industry, pursue the validation of promising subsonic concepts in realistic flight conditions and operating environments.

National Facilities

NASA and DOD are responsible for a large number of unique national facilities that are essential to preserving U.S. leadership in aeronautics. These major government wind tunnels and propulsion facilities, represent the majority of our national aeronautical R&D test capability. They are experiencing significant increases in demand because of new aircraft development programs currently underway across the entire speed range. This demand is expected to grow. Certain of NASA's wind tunnels are aging and in need of modernization. In addition, requirements for higher speeds, higher temperatures, and improved flow and acoustic qualities may require enhanced capabilities. To ensure the health and availability of critical national facilities, the Committee recommends that:

- NASA, in conjunction with DOD and industry, undertake a national assessment of future wind tunnel use requirements and the adequacy of existing wind tunnels to meet these requirements. This assessment should form the basis for developing and implementing a time-phased plan for modernizing, rehabilitating, or removing current NASA wind tunnels from service and for providing new national capabilities.

6 Strengthen American universities for basic research and science education through enhanced government and aerospace industry support and cooperation.

As centers of basic research, universities play a vital role in creating the basic technological foundation for achievement of the National Goals. Universities provide the dual benefit of scientific advances and the training of future scientists and engineers. Yet there are disturbing signs that our universities' R&D infrastructure is deteriorating. The U.S. must revitalize the critically important interactions between universities, government and industry that have served this Nation so well in the past. For these reasons, cooperative efforts between government and industry should be encouraged to help:

- Expand, replace and modernize university R&D equipment, facilities, and instrumentation, to keep pace with research and training needs.
- Support U.S. science and engineering students with adequate long-term stipends to encourage our best students to pursue graduate studies in engineering. Challenging graduate level curricula should be established or strengthened in critical aerospace areas.
- Foster aerospace-oriented centers patterned after such successful ventures as NASA's Centers of Excellence, the National Science Foundation's Engineering Research Centers, and the University Research Initiative of the Defense Department. This will help address critical needs for more multi-disciplinary basic research and encourage greater technology transfer to the private sector.

7 Improve the development and integration of advanced design, processing, and computer-integrated manufacturing technologies to transform emerging R&D results into affordable U.S. products.

Flexible, automated manufacturing technology is a key to affordability and quality in all three goal areas and is a potential major leverage area for U.S. manufacturers. To enhance the U.S. competitive advantage, the Committee recommends that:

- Aerospace industry establish world leadership in advanced processing and computer-integrated manufacturing technology.
- Aerospace industry improve the integration of design with advanced processing techniques and automated factories.
- Federal agencies, particularly DOD, facilitate U.S. manufacturers' use of advanced manufacturing techniques or concepts sponsored by those agencies.
- Industry and government strengthen research activities that can lead to new manufacturing techniques and greater productivity.

8 Enhance the safety and capacity of the National Airspace System through advanced automation and electronics technology and new vehicle concepts including vertical and short takeoff and landing aircraft.

Airport congestion and delay have become substantial problems that will worsen with the expected growth in aviation. New high-performance vehicles will also present significant challenges for the National Airspace System. To realize the benefits of future technology advances, the Committee recommends that:

- Federal Aviation Administration (FAA), in conjunction with NASA, accelerate development and integration of advanced automation and electronics technology into the National Airspace System.
- FAA maintain flexibility for early certification of future aircraft, including supersonic and hypersonic vehicles.
- FAA and NASA provide technology for timely detection and avoidance of hazardous weather such as wind shear, and for computerized aids in handling unavoidable encounters.
- NASA and DOD aggressively pursue advanced automation and electronics technology for future aircraft. Effective integration of humans with these highly-automated systems is pivotal for increased safety and performance.
- Industry explore development of timely and affordable civil derivatives of the new generations of military VTOL and STOL aircraft for intercity and inter-region transportation.

"Universities play a vital role in creating the basic technological foundation for achievement of the National Goals."

CONCLUSION

The Committee believes that the most crucial problem facing U.S. aeronautics is that government and industry leaders underestimate the depth and determination of foreign aeronautical commitment and the magnitude of the R&D effort required to achieve the National Goals. Real national growth in R&D is essential.

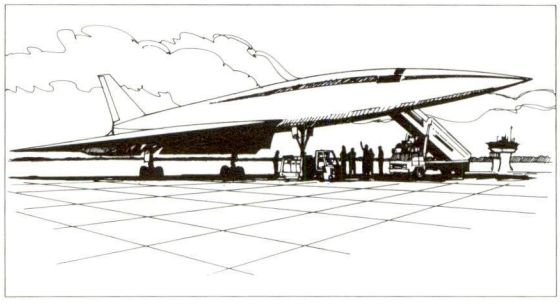
The changing environment requires a new commitment and a new philosophy, characterized by a collective sense of responsibility and a more cooperative relationship among government, industry, and the university community. Government alone cannot guarantee success. America's ability to compete lies primarily within the private sector which must be effectively mobilized. The recommended U.S. strategy will produce both a strengthened defense and a clear-cut product superiority in the international marketplace.

To hold on to American markets while competing in the new global economy requires changes in the aeronautical community's traditional operating procedures. Policies and approaches which were born when U.S. industry was generally preeminent have little place in a world where many competitors are essentially technological equals and actively backed by foreign governments. Major increases in government spending are not required, but necessary outlays will be a prudent investment in America's economic future and national security.

"The central priority for the balance of this century is to regain American competitiveness."

Change is unsettling. Fortunately, many Americans are now recognizing that something different must be done. From education to tax reform, we should be thinking seriously about how to sharpen the country's competitive edge. Otherwise, America's quality of life can only slip relative to the rest of the industrialized world. It is the Committee's hope that all involved will realize that "business as usual" will not carry the U.S. through this world competitive environment successfully.

None of these changes will be easy. The only question is whether they will be made in time with a coherent purpose that will secure lasting U.S. aerospace leadership. Otherwise, far tougher choices will be forced upon us in the heat of a deepening crisis. It is the Committee's firm belief that the central priority for the balance of this century is to regain American competitiveness.



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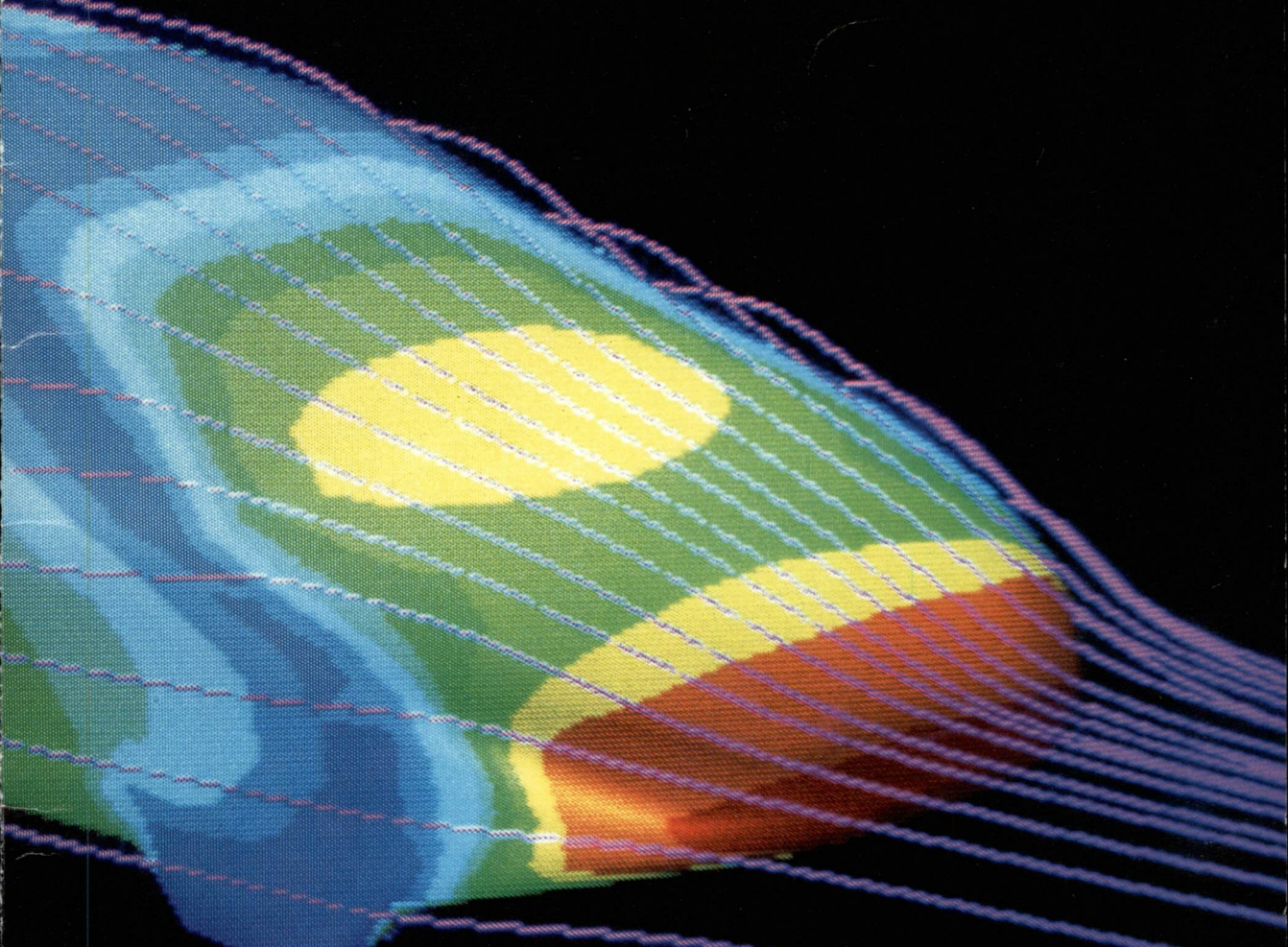
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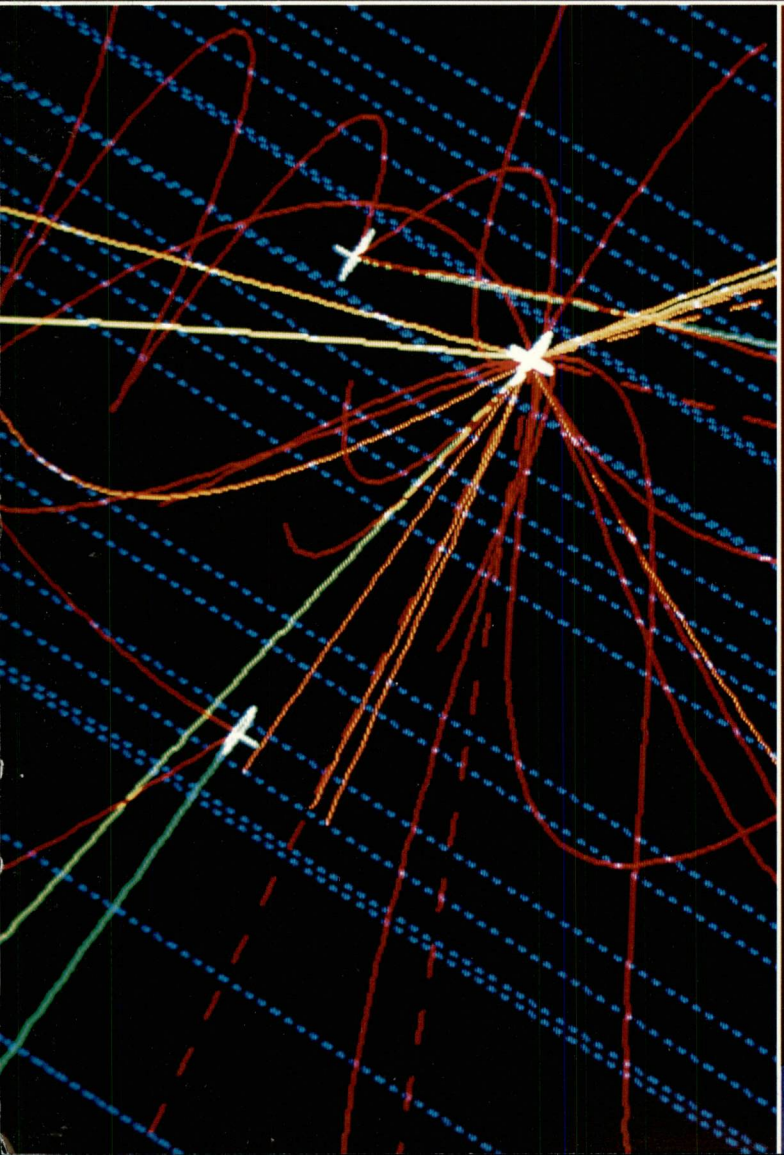
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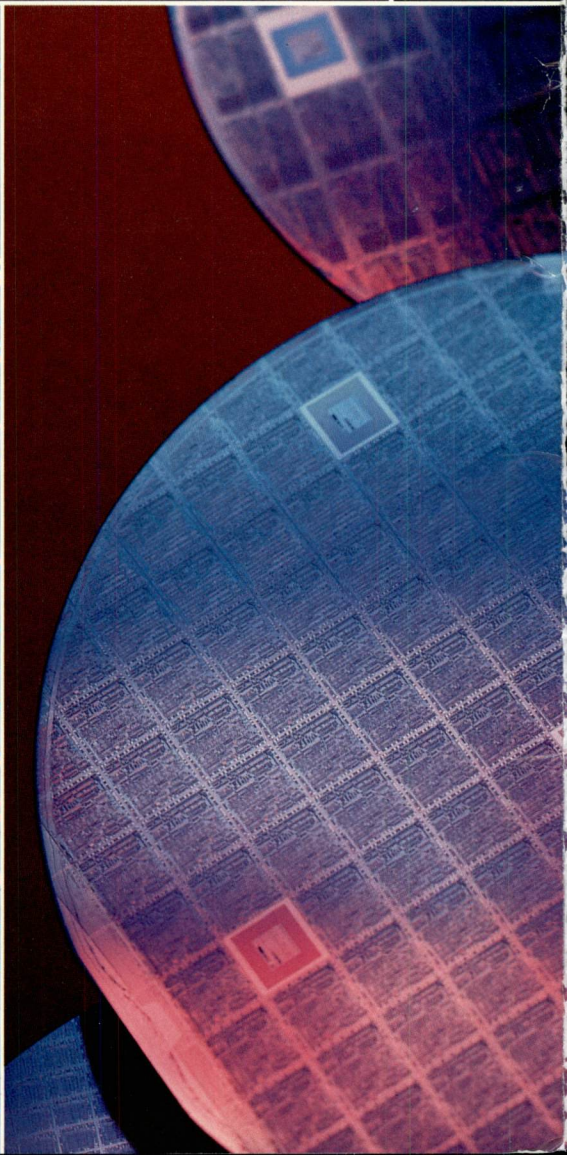
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The U.S. scientific and technological enterprise is still by far the largest in the world. The United States spends more on R&D activities (civilian and military) than do France, Germany, Japan, and the United Kingdom combined. Federal investment in basic research has grown in real terms by over 320 percent since 1960 and by more than 40 percent since 1980 alone. Such growth continues, reflecting the Bush Administration's strong and continuing commitment to the long-established policy of investing in the creation of new knowledge through support of basic research.



Basic research aside, however, a somewhat different picture emerges. Increases in non-federal support and investment in research and development have slackened in recent years. This is a worrisome trend since global economic competition takes place mostly in the private sector and the central role of R&D investment in economic growth is well established. During the 1980s, the average annual real rate of growth for non-federal R&D fell from about 7.5 percent for 1980-1985 to about 2 percent in the early 1990s. Reversing this trend will require not only careful adjustments to Federal policy but enhanced investments on the part of the private sector and a renewed national commitment to educational excellence.

As part of this commitment, the Administration has established a coordinated, government-wide program for improving mathematics and science education, in order to maintain the country's science and technology base and to train a more competitive work force.

Science, as Vannevar Bush pointed out nearly a half century ago, is an endless frontier. Exploiting the opportunities of that frontier has helped to strengthen this Nation and the entire world in the past and can continue to do so in the future. In many ways, investment in science and technology reflects a deep-seated American belief in the possibility of a better future. With concerted action, that future—that endless frontier—lies within our grasp.

— D. ALLAN BROMLEY

The President's Council of Advisors on Science and Technology

In January 1990, President Bush created a new science and technology advisory body, the President's Council of Advisors on Science and Technology (PCAST), and appointed 12 highly distinguished individuals from the private sector to serve on the Council (see chart). The Council is chaired by the Director of the Office of Science and Technology Policy and reports directly to the President. The inaugural meeting of PCAST was hosted by the President at Camp David on February 3, 1990.

The Council responds to the President upon request, and also aggressively maintains a general watch on developments in order to be in a position to raise issues, opportunities, and concerns to the President. The Council's work falls broadly into three categories:

- Science and Technology; The Council work in this area requires broad and in-depth technical knowledge of specific areas of science and technology. Examples include High Performance Computing and Communications; Bioscience and Biotechnology; and the Global Environment.
- Policy; Efforts here involve policy for science and technology as well as science and technology for policy. Examples include advice on priorities for Federal expenditures in science and technology as well as science and technology advice on issues involving manufacturing and U.S. economic competitiveness.
- Organizational; This work addresses structural and strategic management policies related to science and technology including policies within the Federal Government as well as policies in non-governmental organizations. An example is the Council's work in Science, Technology, and National Security.

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Serving National Needs

In the brief span of their existence, modern science and technology have proved to be powerful social and economic forces. Increasingly, they are the source of new discoveries and advances that are transforming the industrial basis of modern economies, improving health care and the quality of life, and providing a continuing supply of military capabilities. Equally important, science serves to satisfy human curiosity and to expand intellectual horizons.

We live in a time of unprecedented change, and not just in science and technology. Revolutionary changes in political and social organization are occurring in the former U.S.S.R. and in Eastern Europe, Africa, South America, and Asia. A new and more competitive global economy is emerging. National security concerns face a major transformation, yet we will depend more than ever on R&D to maintain a U.S. technological edge. The potential threat of global climate change and other potential or actual environmental changes caused by human activity intensify the need for improved knowledge of fundamental Earth system processes.

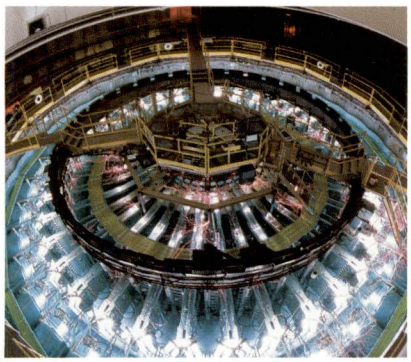
The Bush Administration has moved decisively to meet these challenges, in part by more effectively harnessing science and technology to meet national needs. It has:

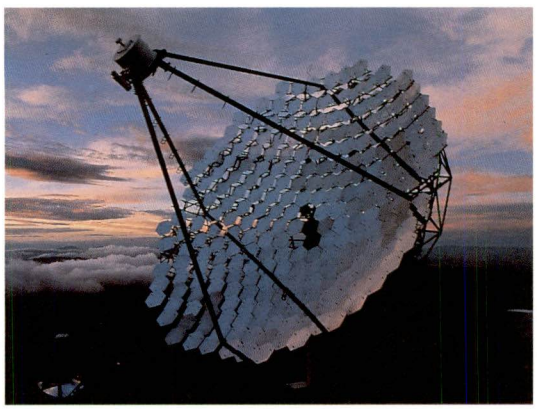
- reorganized and upgraded the Federal government's ability to deal with science and technology;
- increased Federal investment in the creation of new knowledge;
- established a technology policy to achieve the national goals of improved quality of life for all Americans, continued economic growth, and national security;
- recognized unmet needs in translating new knowledge into new products and services by identifying and supporting generic, pre-competitive technology development in cooperation with the private sector;
- moved to reduce barriers to competitiveness;
- established a coordinated, government-wide effort to improve science and mathematics education;
- sought to increase international cooperation in science and technology; and
- established a comprehensive strategy on climate change which includes the promotion of economic growth and sound environmental policies.

Basic Research Foundations

Basic research is the foundation of the nation's research and development enterprise. It generates the new ideas, concepts, techniques, and tools upon which both science and technology endeavors are based. As such, basic research is the fuel for new products and processes that stoke the engine of economic growth and improve the quality of life.

The quest for scientific understanding is one of mankind's great adventures. Since about half of U.S. basic research is done in academic institutions, the adventure also provides the advanced training experience for future generations of research scientists. It enriches the educational environment in which scientists and engineers receive their undergraduate training.

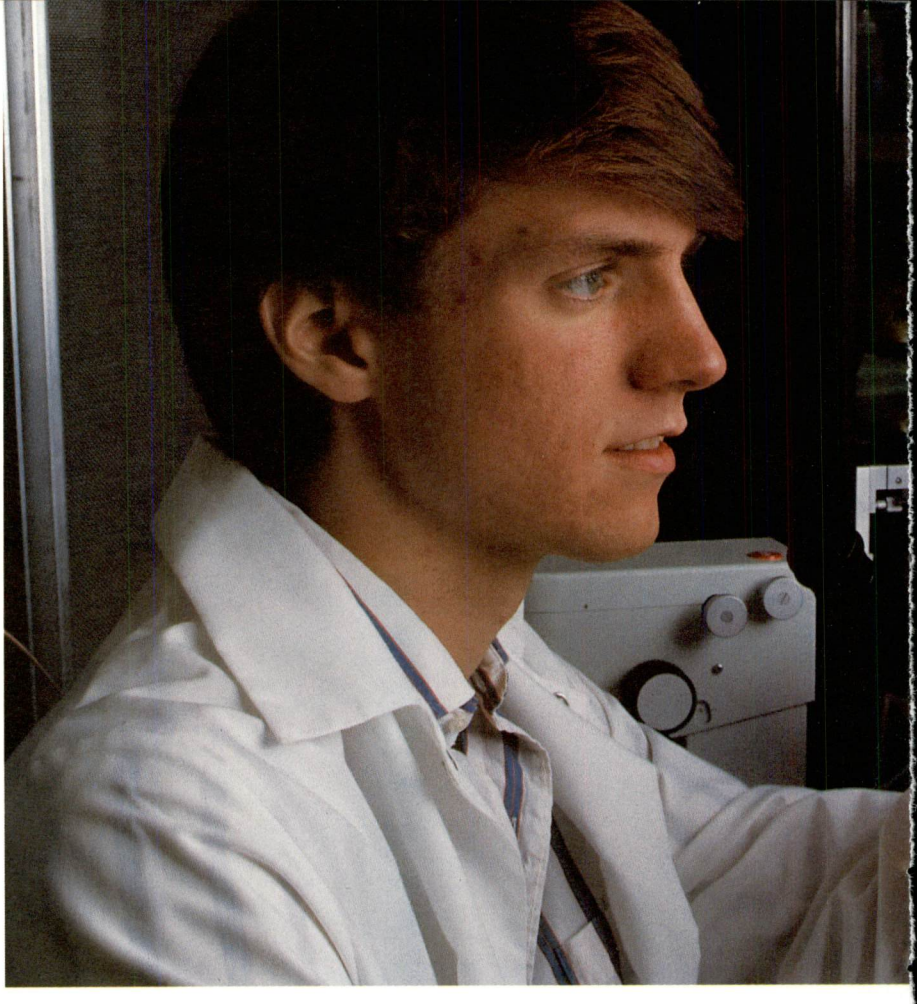




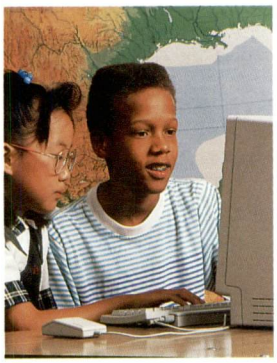
An optical fiber illuminated by a light source (right); particle beam fusion accelerator using 36 beams of atomic particles to generate x-rays (below); telescope at the Whipple Observatory, Arizona (bottom).

The U.S. basic research system is uniquely productive, measured not only by the number of Nobel Prizes won by U.S. researchers but also by the degree to which U.S. research literature is cited by other scientists. Modern basic research has outgrown a narrow focus on a single discipline and now increasingly involves many disciplines in cross-cutting research to fully understand aspects of nature. Much attention has been devoted by the Bush Administration to facilitate the support of cross-disciplinary basic research while preserving and building the strength of the base scientific disciplines. Interagency Presidential initiatives, coordinated by the Office of Science and Technology Policy through the Federal Coordinating Council for Science and Technology, include High Performance Computing and Communications, Advanced Materials, Processing Biotechnology, and Global Climate Change Research; each contains a significant basic research component.

The Federal government is appropriately the primary source of support for the conduct of basic research, providing $13.3 billion for this purpose in 1992. Expenditures of Federal funds for basic research have grown over 320 percent in real terms since 1960, and over 40 percent during the 1980s alone. The Office of Science and Technology Policy works with the Office of Management and Budget and the Federal funding agencies to strike an appropriate balance between support for individual investigators and large basic research projects, and between basic research and other critical Federal R&D responsibilities.



Learning by doing in the laboratory (right); elementary school computer class (below); pre-college science class (far right).

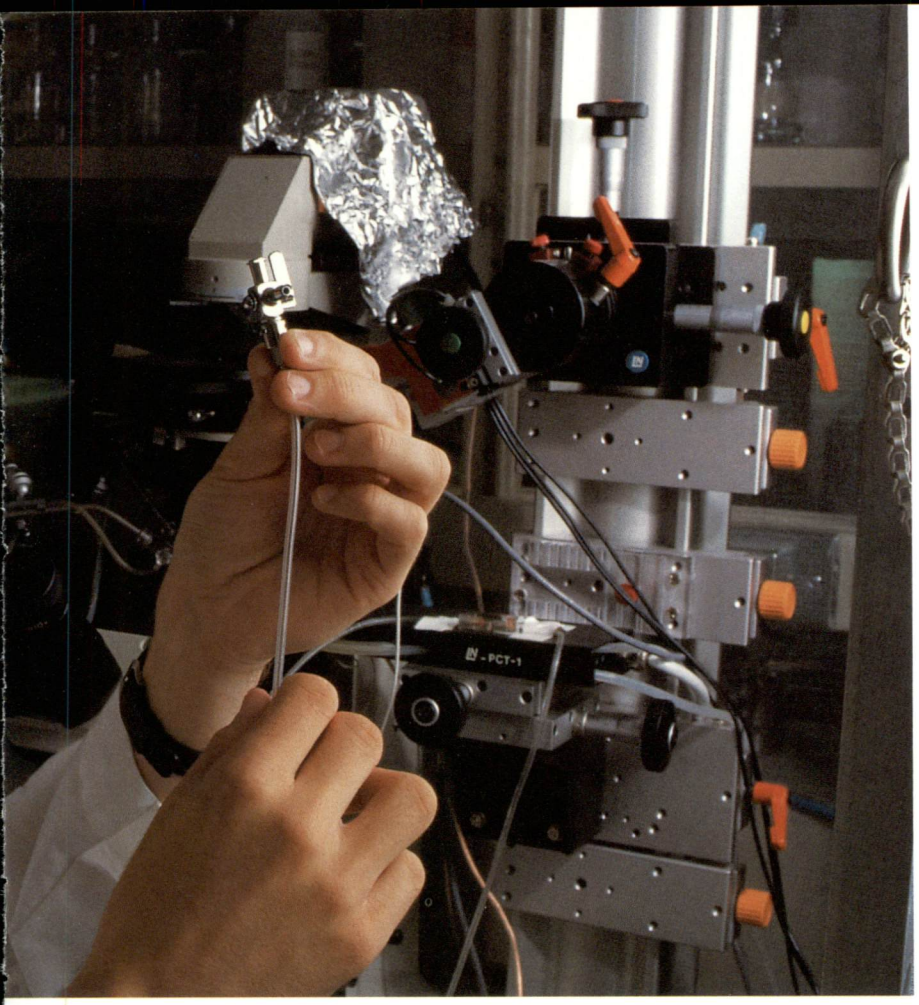


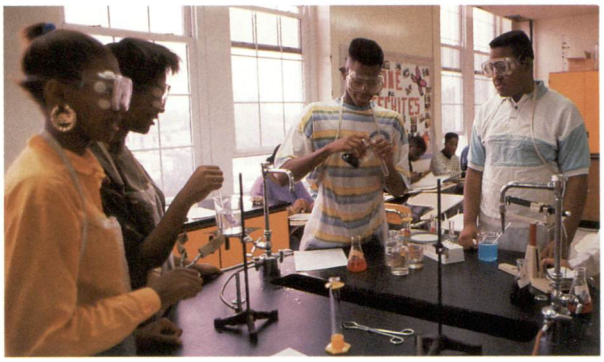
Educating the Minds of Tomorrow

America is facing a crisis in science and mathematics education, a crisis that extends throughout the U.S. educational system but is most serious in elementary and secondary education.

To respond to this crisis, President Bush, in September 1989, convened the Nation's first Education Summit with the State Governors. The Summit led to the establishment of six national goals for improving education in the United States. The ongoing efforts to strengthen education received further impetus in April, 1991, when President Bush announced AMERICA 2000, a long term national strategy to move the United States toward the six national education goals.

While primary responsibility for education will remain with the states and localities, the Bush Administration has established a coordinated interagency program, budget, and strategy for science and mathematics education. The program was developed under the auspices of the Office of Science and Technology Policy and the Office of Management and Budget through the Federal Coordinating Council for Science, Engineering, and Technology. The



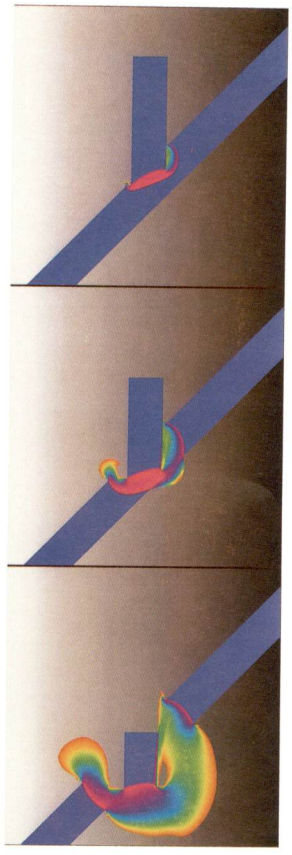


President's initiative gives priority to precollege education, with the single most important near term action in mathematics and science education being to enhance the quality and enthusiasm of teachers now in the classroom. At the same time, there is a focus on strengthening undergraduate education and preserving U.S. leadership in graduate education. Reform of mathematics and science education is a major task within, and wholly complementary to, the broader AMERICA 2000 education strategy.

Improved achievement in science and mathematics education, the goal of the President's program, is central to economic competitiveness because research and development—and the consequent improved technologies, new knowledge, products and processes—play a crucial role in improving economic productivity. At the same time, more efficient U.S. factories and service industries of the future require a work force that is second to none in technical skills related to mathematics and science achievement.

High Performance Computing and Communications

High performance computers and the data networks that connect them are becoming increasingly important to scientific advancement, economic competition, and national security. The technologies have the potential for extraordinarily rapid advances within the next five years—a 1000-fold improvement in computing speed and a 100-fold improvement in the transmission rate of data networks. Such developments could have transforming effects on industry, educational institutions at all levels, and society as a whole.



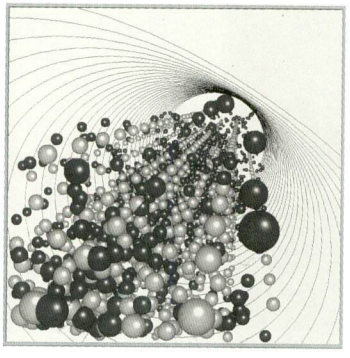
The Connection Machine (right), one of the first massively parallel supercomputers; collision of a cylinder and a wall simulated on a supercomputer (top); simulation of an electron beam (bottom).

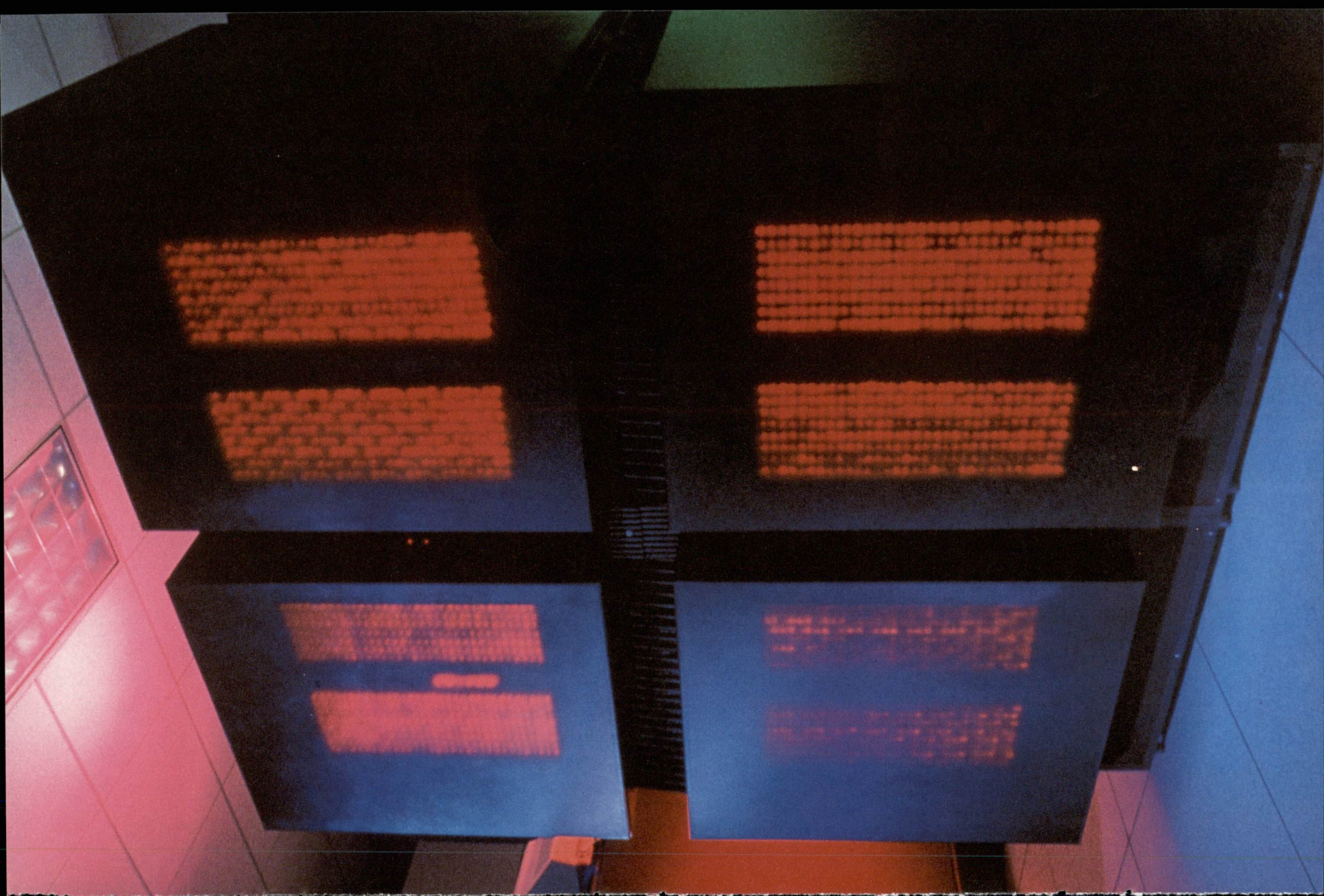
Underlying such advances is a radically different approach to computing that is known as parallel processing. Unlike most of today's computers that have one processor and perform only one task at a time, parallel processing computers can do a thousand or ten thousand things simultaneously, depending on how many processors they employ.

High performance computing is expected to enhance research by making possible the solution of critical scientific problems, to transform the process of product design and production throughout the U.S. economy, and to contribute in an essential way to national security and national defense. High capacity networks will provide easier access to high performance computers and to the vast stores of information that exist in laboratories, government agencies, museums, and libraries.

The Bush Administration has established a Presidential Initiative on High Performance Computing and Communications, comprising a coordinated interagency research program developed under the auspices of the Office of Science and Technology Policy and the Office of Management and Budget through the Federal Coordinating Council for Science, Engineering, and Technology. The program provides for development of these revolutionary technologies within the framework of an enthusiastic partnership among government, industry, and universities.

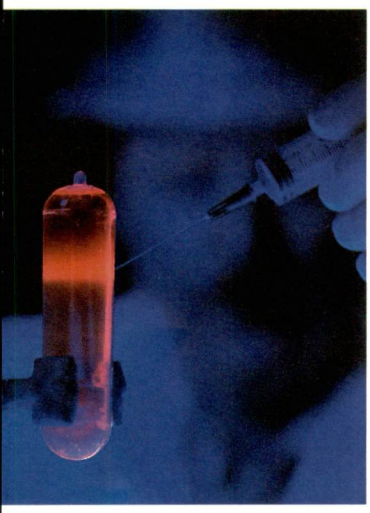
The High Performance Computing Act of 1991, signed into law by President Bush on December 9, 1991, provides a strong congressional endorsement of the initiative. In time, this visionary initiative will be seen as a watershed event in computing and communications.







Petri dishes showing bacterial, fungi, and yeast cultures (right); purified DNA under ultraviolet light (below); electron micrograph of a flower pistil (far right).



Life Sciences and Biotechnology

From a beginning only 20 years ago, scientists have learned to alter precisely the genetic constitution of living organisms, initiating a scientific and industrial revolution based on what we now call the new biotechnology.

The new biotechnology is a rapidly expanding collection of tools and technologies that permits change and modification of the genetic material of living organisms. It opens the way to the production of large quantities of rare and medically-valuable proteins and the modification of plants and animals to carry specific hereditary traits. It also provides novel means for detecting and preventing disease, producing useful chemicals, and cleaning up environmental contamination. In just a decade and a half, this nascent field has grown to produce U.S. products worth $4 billion annually. Already, an increasing proportion of new drugs approved for life-threatening diseases are biotechnology products.

Biotechnology industries have the potential to join the computer industry in size, importance, rate of growth, and significance to the economy.



The Bush Administration is taking decisive action—including a national Biotechnology Research Initiative—to assist U.S. leadership and competitiveness in biotechnology and to enhance its role as an essential element in a growing and vigorous economy. The Office of Science and Technology Policy as well as the Competitiveness Council are giving priority attention to measures that can facilitate new discoveries and bring them to the market place:

- Securing the science and technology base by supporting basic research and research training;
- Avoiding unneeded regulation by matching regulatory restraints to the degree of risk posed by specific products;
- Sustaining a vigorous market for biotechnology products by promoting capital investment and protecting intellectual property rights.



Given its broad range of applications, biotechnology offers potential benefits to every nation. In fact, biotechnology is the essential key to enriching Earth's productivity without depleting precious resources and to gaining, for human benefit, full use of our vast genetic heritage accumulated over billions of years.

Science, Technology and National Security

America's scientific and technological strength has long provided the qualitative edge that ensured the nation's security and helped preserve the peace. This technological edge was clearly demonstrated in Operation Desert Storm. The superiority of the current generation of U.S. weapons is a direct result of decisions made in years past to harness American technical ingenuity and creativity and to develop military systems of unparalleled performance and quality. Costly though some are, these systems have saved the lives of many U.S. servicemen and women as well as countless civilians. As the U.S. enters the 1990s, the strength of our basic and applied research in defense technologies must be sustained.

F-15 fighter moves in for refueling during Operation Desert Shield (right); Defense communications satellite (below); Patriot missile battery on alert (bottom).





In providing for the nation's security, we need a defense research and technology base that will guard against technological surprise and will keep the United States in the lead in uncovering the rare revolutionary technology breakthroughs and in exploiting evolutionary improvements that define tomorrow's military advantage. The intelligence community also needs creative and productive R&D programs to meet the collection and analysis requirements of the future. The Office of Science and Technology Policy is working to ensure appropriate levels of investment in critical and cutting edge technologies central to tomorrow's defense and to maintain a robust defense and intelligence establishment that is ready for the challenges of a changing world.

The conflict in the Gulf and the dramatic developments underway in Eastern Europe and the former Soviet Union presage far-reaching changes in the international environment and in the security needs of the West. With the globalization of technology and the spread of weapons of mass destruction, even a relatively unsophisticated society can threaten the U.S. and its allies. The development and application of technology to support changing defense, foreign policy, and intelligence requirements are central concerns of the Bush Administration.





Science, Technology and Foreign Policy

Major global trends in recent decades have placed science and technology ever closer to the center of international issues. Despite the current restructuring of the world order, U.S. national security needs have not diminished. As the Gulf War illustrated so vividly, technology is, more than ever, critical to national security. And in economic terms, the world has become more intensively competitive. As the successes of Japan and the Asian "tigers" have shown, technology can provide the competitive edge in economic growth. Finally, national concerns about global trends in our physical and human environment are appearing with increasing frequency on the international agenda. Developing an adequate understanding of the complexities of global change requires major internationally-coordinated research efforts.

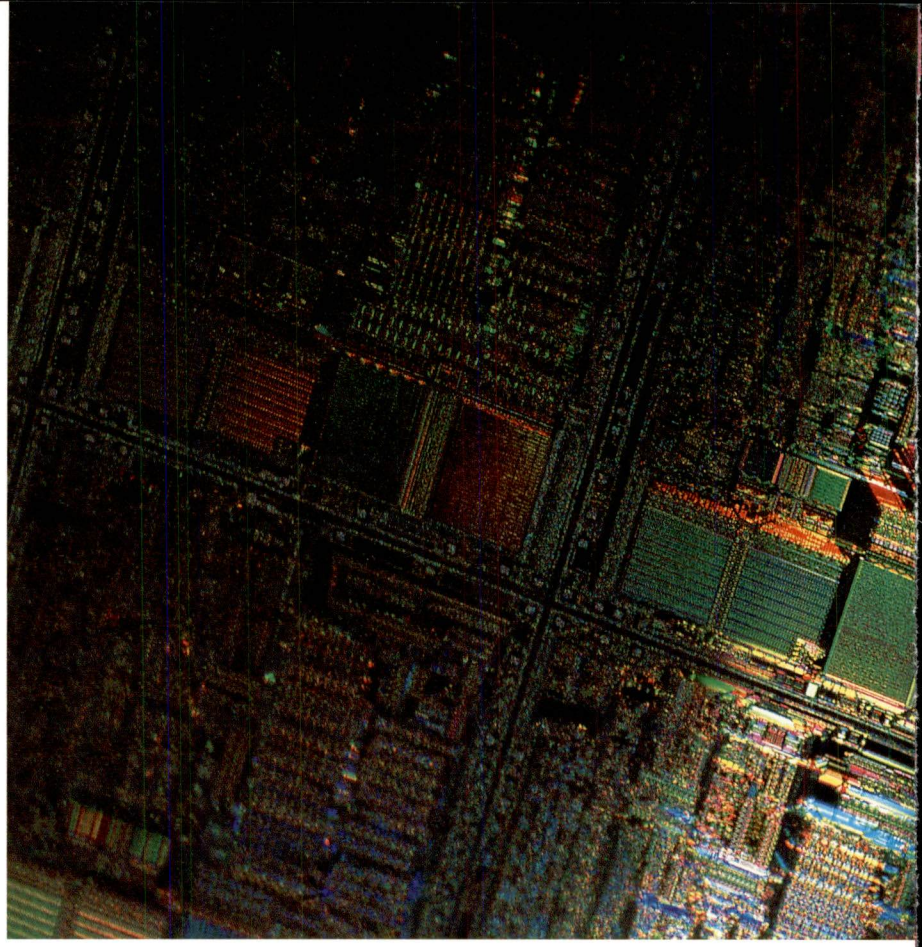


Researcher checks rocks for microorganisms in Antarctica (left); National Science Foundation research base at McMurdo Sound (above).

The international character of the science and technology enterprise is increasing steadily. Industrial activity is becoming more global. Academic scientists are becoming more involved in international exchanges. Federal agencies and their laboratories are becoming more active in international cooperation. However, since the national security and economic interests of the United States are affected by the flow of technology and technological knowledge, the Federal government promotes or limits that flow, as appropriate to the national interest.

International scientific and technological cooperation, fostered by the Federal government through government-to-government agreements and other means, promote the foreign policy interests of the United States while providing benefit to our science and engineering communities. In cooperation with the policy coordination by the National Security Council, the Office of Science and Technology Policy provides necessary coupling among the Department of State, which has statutory responsibility for international agreements, and the Federal agencies which manage the substantive programs of cooperation in science and technology.

The Bush Administration's vigorous policy toward international cooperation in science and technology incorporates steps to ensure "a level playing field" in areas such as the protection of intellectual property rights and equal access to research facilities.

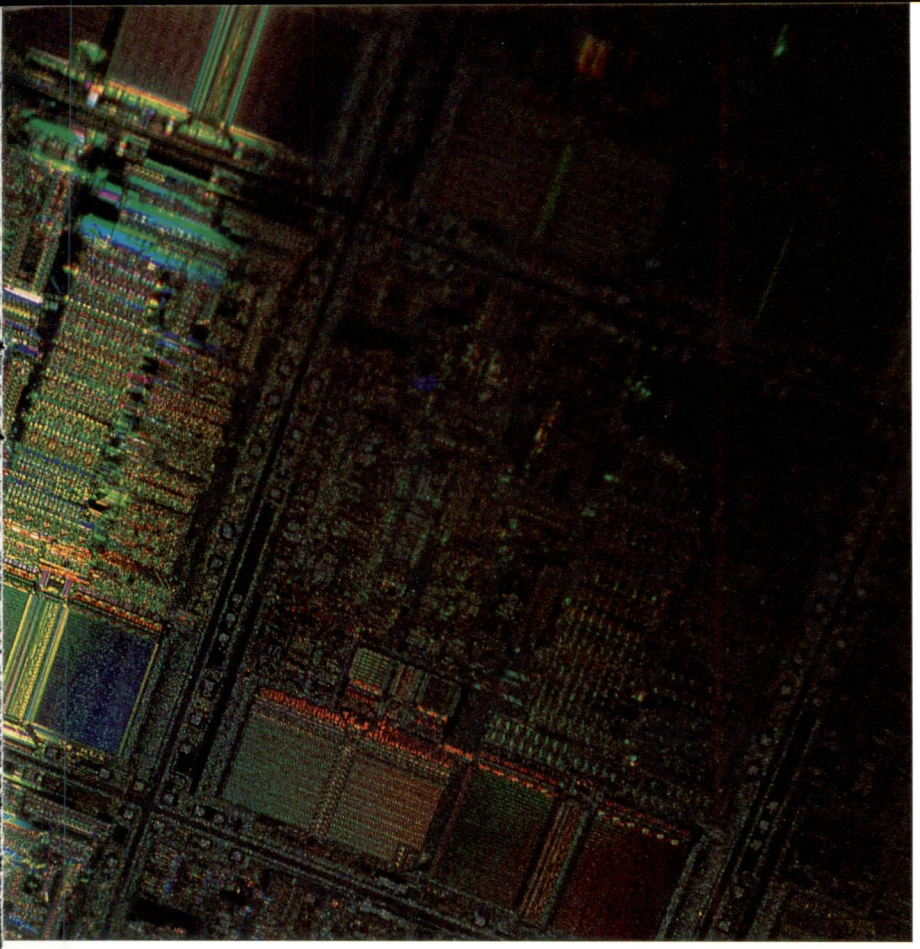


Increasing Competitive Advantage through Science and Technology

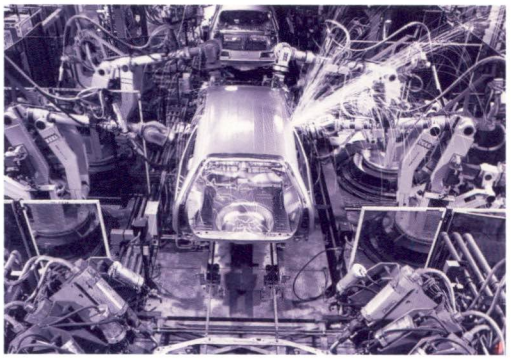
Technology is a major factor driving economic growth. For 150 years, technological innovation has helped to create new jobs and improve living standards. More recently, most of the great post-war inventions—computers, microelectronics, genetic engineering, fiber optics, to name but a few—have been "made in America". To retain world industrial leadership, however, we must continue our commitment to the discovery of basic knowledge and new understanding, foster the timely translation of ideas and discoveries into new products, and revive the great American tradition of manufacturing so that we not only start, but sustain and retain new industries.

To this end, the Bush Administration published a report on U. S. Technology Policy in September, 1990. Prepared by the Office of Science and Technology Policy in cooperation with the Office of Management and Budget and the Council of Economic Advisors, it is the first such report issued by any Administration.

The U.S. Technology Policy recognizes that the private sector has the principal role in identifying, developing, and applying technology for commercial products and processes. The Federal government's role is in establishing an



economic environment that fosters savings and stimulates investment both in research and development and in plant and equipment; funding basic research; and jointly supporting, with industry, generic technologies; providing a stable and sensible regulatory system; encouraging cooperative government-industry relationships; seeking better international protection of intellectual property; and similar actions.



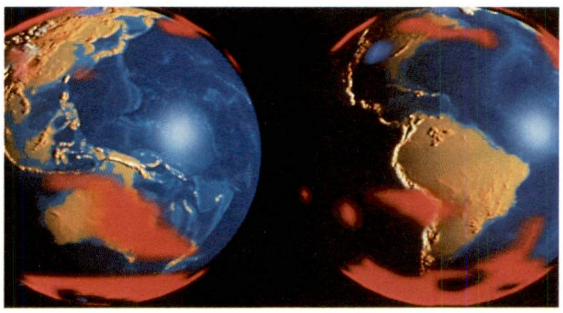
Section of a microelectronic chip (top); an automated assembly line (above).

The Bush Administration's strategy is to invest directly in areas that support agency missions but also have broad applications in the private sector. In support of this strategy, it has established Presidential Initiatives, developed under the auspices of the Office of Science and Technology Policy and the Office of Management and Budget through the Federal Coordinating Council for Science, Engineering, and Technology. These initiatives will help bridge the gap between discovery and commercialization, create new and better jobs for American workers, and increase economic growth. Areas of special focus are biotechnology, high performance computing and communications, advanced materials and processing, and flexible manufacturing.

Global Change

During the past century, human society has entered into a new and momentous relationship with the global environment. As the human population and the scale of industrial civilization have increased, so has their impact on the Earth. For the first time in history, the scope of human activities is sufficient to significantly influence the entire planet.

Already some of these activities have led to the partial degradation of the atmosphere's protective ozone shield. A far more complex potential threat to the global environment is the possibility that human actions will lead to an intensification of the "greenhouse effect" and thus to a significant warming of the Earth's climate.



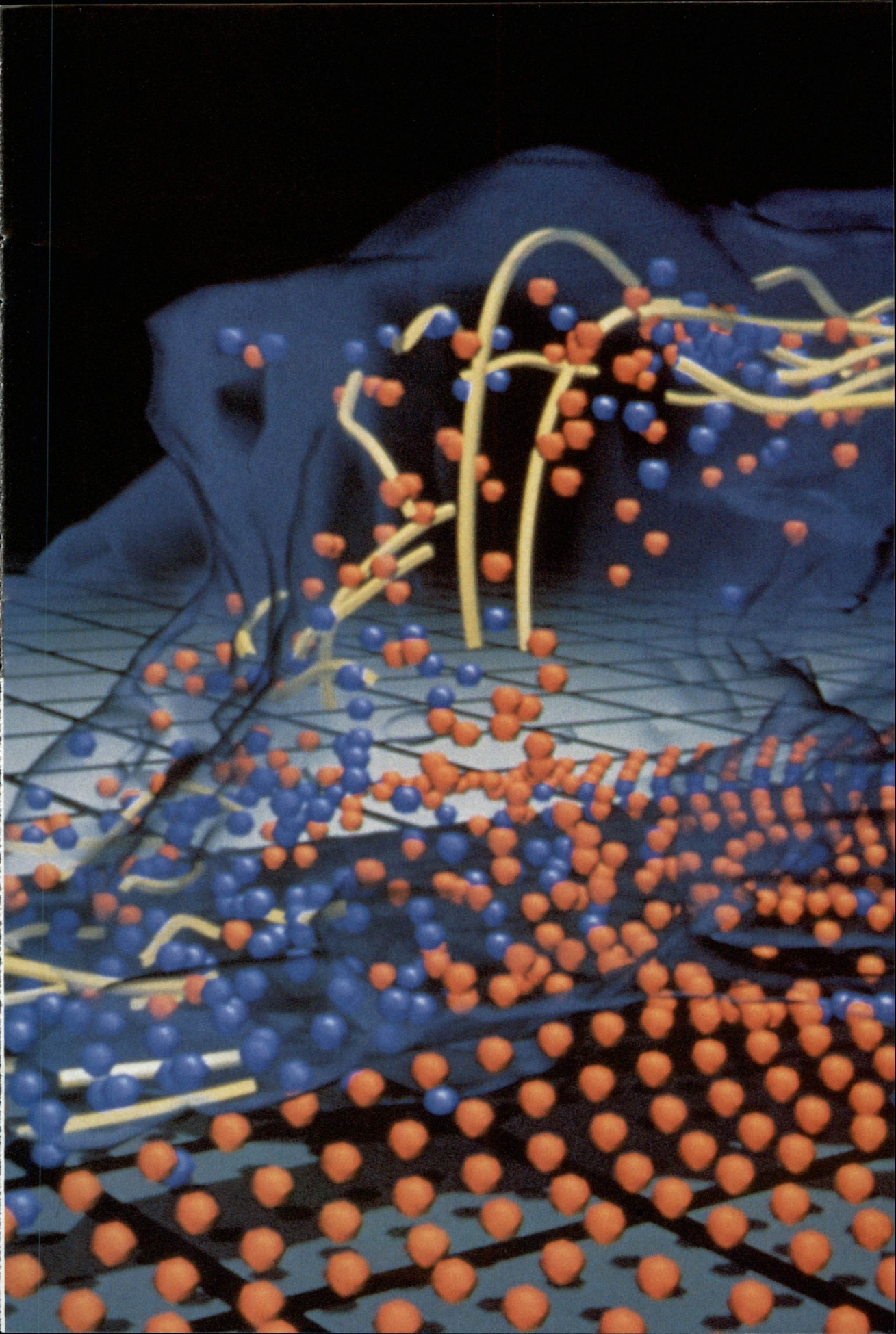
Computer simulation of a severe storm (right); simulation of global climatic effects of increased greenhouse gases (above).

To create prudent long-term environmental policies requires a much improved scientific understanding of the Earth system, how it changes naturally, how human activities change it, and how it might respond to future changes in environmental conditions.

A key component of the Administration's overall approach to global stewardship is the U.S. Global Change Research Program. This Presidential Initiative, comprising a coordinated interagency research effort, was developed under the auspices of the Office of Science and Technology Policy and the Office of Management and Budget through the Federal Coordinating Council for Science, Engineering, and Technology. It centers on four broad problem areas or themes:

- Global water and energy cycles, focusing on a better understanding of the role of clouds, oceans, terrestrial ecosystems, and polar ice sheets;
- Global carbon cycle, focusing on a more precise knowledge of sources and sinks of key carbon compounds such as carbon dioxide and methane and their behavior within the Earth system;
- Ecological systems and populations of living organisms, focusing on the effects of global change at regional scales;
- Climate modeling and prediction, building on all of the above efforts to develop an improved predictive capability of the Earth system.

The main task of the Program is to develop a productive understanding of the Earth system; it is to be complemented by economic research to better understand the economic factors and consequences of global change.



Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP), together with the Office of Management and Budget, provides a central locus for science and technology affairs within the Executive Office of the President. OSTP is charged with providing access to authoritative information and expert scientific, engineering and technological advice for the President, Federal officials, and Congress and with coordinating science and technology policy throughout the Federal Government. The Director of OSTP is also the Assistant to the President for Science and Technology and thus a senior member of the White House staff; chairman of the Federal Coordinating Council on Science, Engineering, and Technology; and chairman of the President's Council of Advisors on Science and Technology.

The office works closely with a number of high level policy organizations and councils in the Executive Office of the President. The Assistant to the President for Science and Technology is chairman of the science and technology working group of the Policy Coordinating group. He is a member of the National Space Council. In addition, he participates in the deliberations of the National Security Council and the Competitiveness Council. OSTP also works closely with the Office of Management and Budget and with more than 20 federal agencies on R&D budgets and with the Council of Economic Advisors and the Council on Environmental Quality on issues such as global change that have scientific, economic, and environmental policy implications.

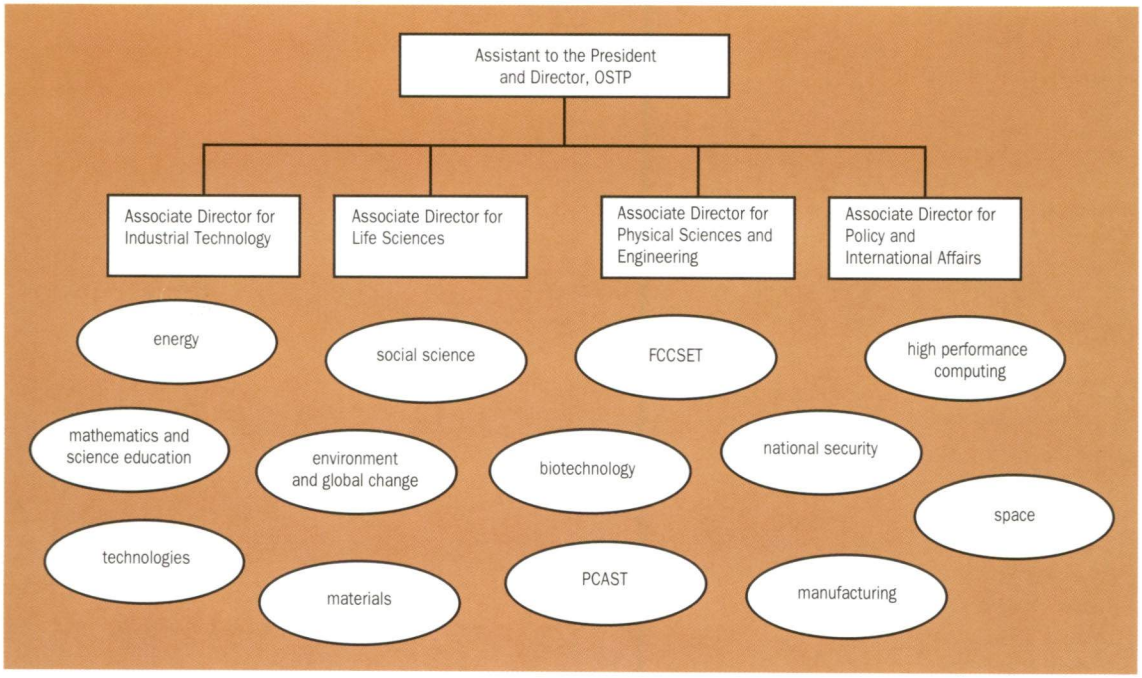
OSTP works with the Federal agencies that support R&D to ensure the health

OSTP Director D. Allan Bromley with President Bush during a working meeting.



and vitality of the U.S. science and technology bases and reviews Federal science and technology programs to ensure that the Nation's R&D resources are used efficiently. The Office also provides information, advice, and analysis on broad national and international policy issues that involve important science or technology components and serves as the U.S. focus for many bilateral and multilateral international agreements in science and technology.

OSTP Organization Chart



Under the Bush Administration, OSTP now incorporates a greater concern with technology as well as with science. The Office now includes four Presidentially-appointed, Senate confirmed, Associate Directors who together with the Director carry responsibilities for industrial technology; national security; life sciences; social sciences; physical science and engineering; policy and international affairs; environment; and other areas (see chart).

The Director of OSTP has been appointed by the President to the chairmanship of the Operating Committee of the Critical Technologies Institute and to membership in the National Critical Materials Council.

OSTP was established by statute in 1976, but can trace its origins back to World War II and the success of the wartime Office of Scientific Research and Development. The first science advisor to the President was named in 1958, after the launch of Sputnik showed the need for a permanent office close to the President. The current director of OSTP, Dr. D. Allan Bromley, was appointed by President Bush on August 4, 1989.

The Federal Coordinating Council for Science, Engineering and Technology

FCCSET MEMBERS

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The Honorable D. Allan Bromley
Assistant to the President for Science & Technology and Director, Office of Science and Technology Policy

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The Honorable Donald J. Atwood, Jr.
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Secretary of Energy

The Honorable Alfred DelliBovi
Under Secretary, Department of Housing and Urban Development

The Honorable Lamar Alexander
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The Honorable Richard Austin
Administrator, General Services Administration

The Honorable Richard G. Darman
Director, Office of Management and Budget

The Honorable Daniel S. Goldin
Administrator, National Aeronautics and Space Administration

The Honorable William K. Reilly
Administrator, Environmental Protection Agency

The Honorable Brent Scowcroft
Assistant to the President for National Security Affairs

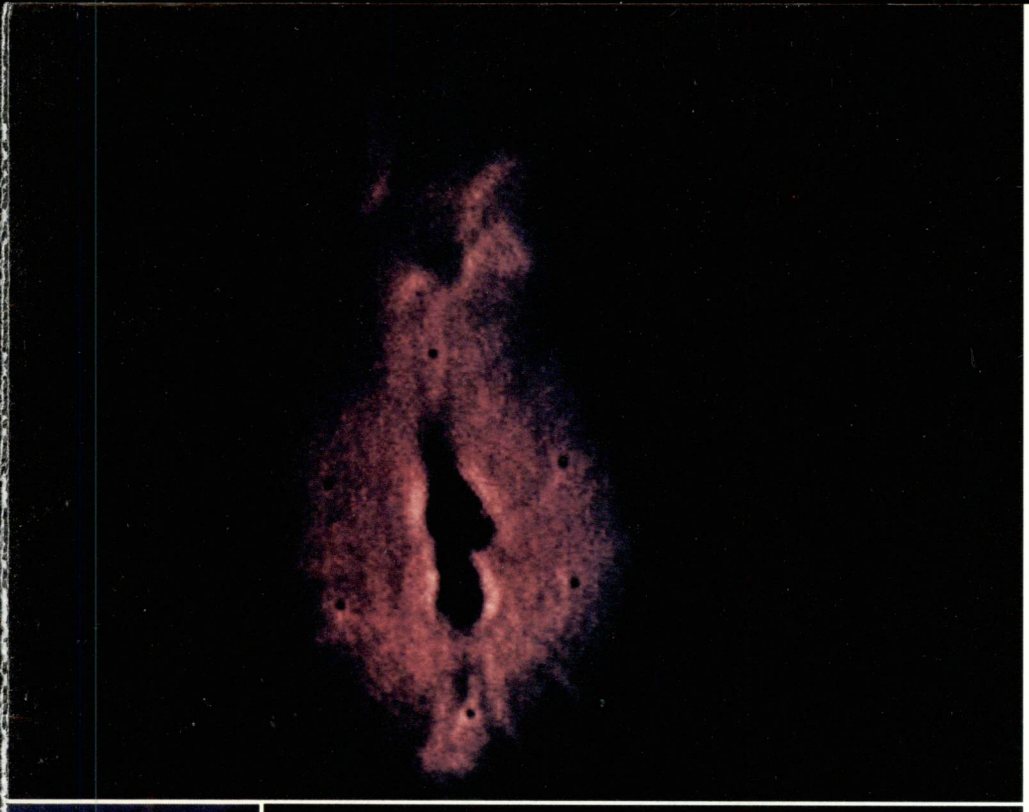
The Honorable Walter E. Massey
Director, National Science Foundation

The Federal Coordinating Council for Science, Engineering and Technology was established in 1976 to address science and technology policy issues affecting multiple Federal agencies. The Council is an important means for coordinating Federal R&D programs and other multi-agency science and technology activities. It also provides a mechanism for focusing attention on science, engineering and technology policy issues within the Federal agencies.

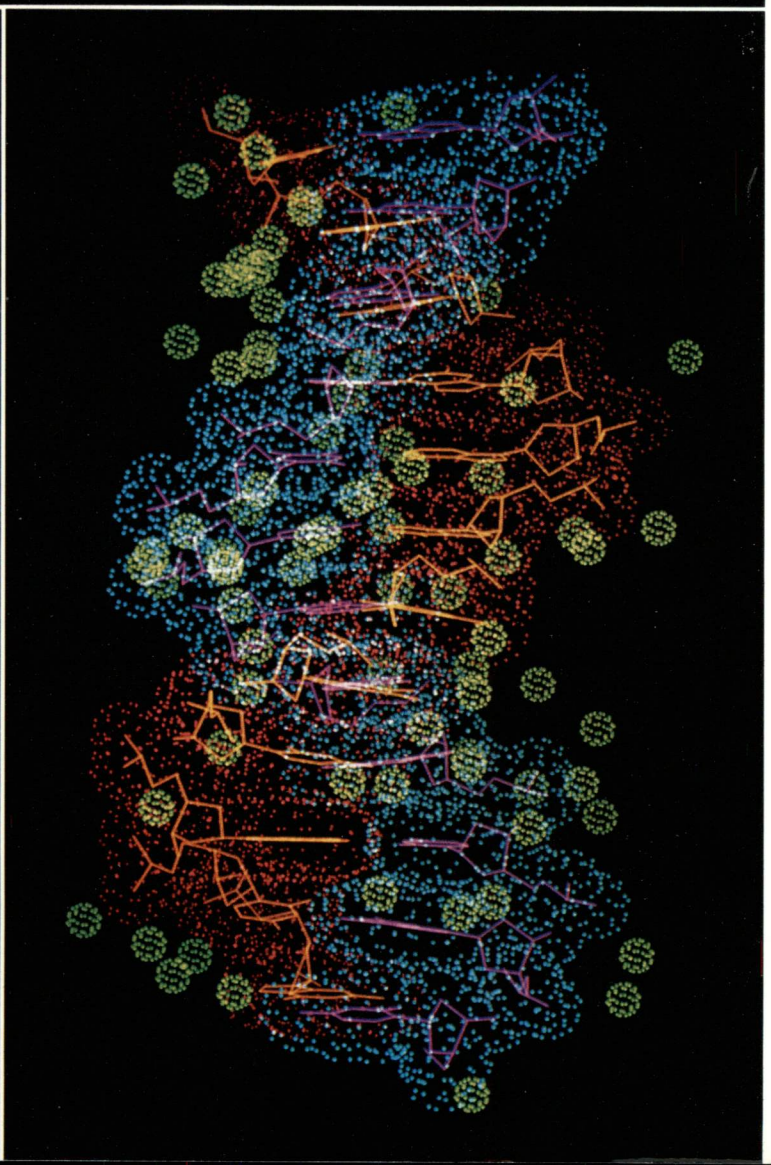
The Council is chaired by the Director of the Office of Science and Technology Policy and is comprised of Cabinet members or their deputies from the major Federal Departments and the heads of Federal science agencies (see chart). In Fiscal Year 1992, these departments and agencies collectively accounted for approximately $74 billion in Federal R&D expenditures.

The interagency nature of the Council makes it a critical body for the planning, budgeting, and coordination necessary to set government-wide priorities on cross-cutting R&D initiatives and to ensure efficient use of Federal R&D resources. For this purpose, the Council has established seven high-level, interagency standing committees spanning broad areas of science and technology.

In close cooperation with the Office of Management and Budget, the Council and its committees develop coordinated, integrated strategies, programs, and budgets for Federal research and development in high priority, cross-cutting areas of science and technology. The areas include: global change, high performance computing and communications, biotechnology, advanced materials and processing, and mathematics and science education. Interagency groups also are examining topics ranging from coastal ocean science, genome patenting, and natural disaster reduction to the structure of international science and technology agreements. In each case, the goal is to achieve consensus that can then guide the actions of participating agencies.

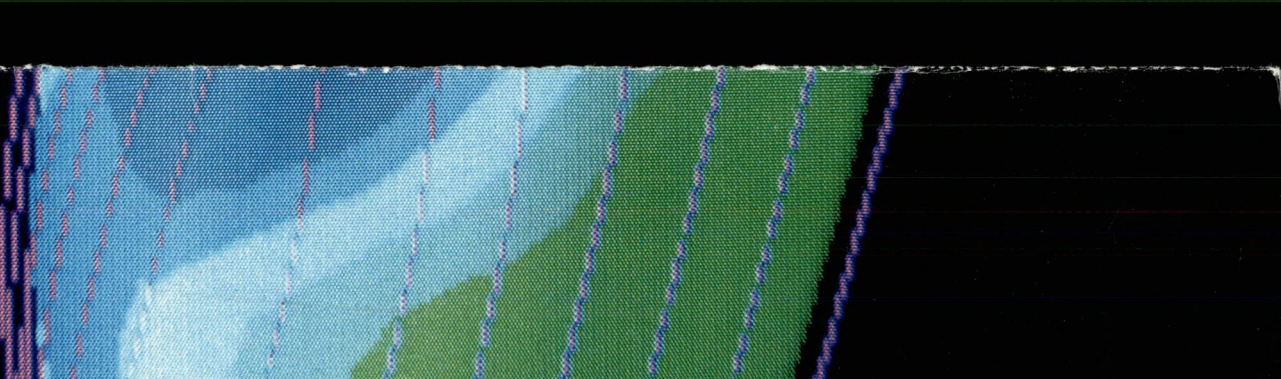


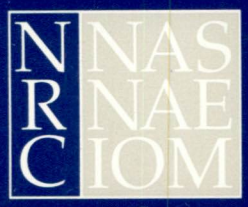




(clockwise from left) False-color composite satellite image of Earth's biosphere showing showing distribution of vegetation and phytoplankton; Hubble Space telescope image of exploding star R. Aquarii; computer graphic image of the B form of DNA showing double helix structure; silicon wafers; computer simulation of an electron-positron collision in a high energy physics detector.

Photo credits: cover, Hank Morgan (Rainbow); inside front cover (clockwise from top), NASA, NASA, Photo Researchers, Rene Sheret, Photo Researchers; page 2-3, Dan McCoy (Rainbow), Sandia National Labs, Smithsonian Institution; page 4-5, NIH/NINDS, Apple Computer, National Cancer Institute; page 6-7, National Center for Supercomputer Applications, Sandia National Labs (2); page 8-9, Kay Chernush, National Cancer Institute, David Scharf/Peter Arnold Inc.; page 10-11, Department of Defense (3); page 12-13, National Science Foundation (2); page 14-15, Rene Sheret, Ford; page 16-17, National Center for Supercomputing Applications (2); page 18, White House photo; cover 3, NASA.





Reorientation of the Research Capability of the Former Soviet Union

A Report to the Assistant to the President for Science and Technology

REORIENTATION OF THE RESEARCH CAPABILITY OF THE FORMER SOVIET UNION

A Report to the Assistant to the President for Science and Technology

Results of a Workshop on March 3, 1992

Co-Chairmen of the Workshop

Frank Press
Guyford Stever
Ashton Carter

Chairmen of the Working Groups

Ashton Carter, Weapons Scientists and Engineers
James Wyngaarden, Basic Research
Gerald Dinneen, Commercialization of Technologies
Alvin Trivelpiece, Multidisciplinary, Problem-Oriented Research

National Academy of Sciences
National Academy of Engineering
Institute of Medicine

National Academy Press
Washington, D.C. 1992

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

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

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

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

Support for this project was provided jointly by the Carnegie Corporation of New York and the National Research Council.

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OFFICE OF THE PRESIDENT

March 13, 1992

Dr. D. Allan Bromley
Assistant to the President for Science and Technology
Executive Office of the President
Office of Science and Technology Policy
Washington, D. C. 20506

Dear Dr. Bromley:

As you requested, we brought together on March 3 approximately 120 leaders of the U.S. science and engineering community to consider how to preserve the basic science capability of the former Soviet Union (FSU). At that meeting, working groups were constituted in four areas: weapon scientists and engineers, basic research, commercialization of technology, and interdisciplinary problem-oriented research (e.g., health, ecology, energy, polar, etc.). Attached are the reports of these four working groups along with the list of attendees.

As co-chairs of the meeting, we are providing in this letter a summary of the key recommendations and observations drawn from the discussions. Because of the urgency of providing this response, we have not circulated this letter to the attendees for review prior to sending it to you. We take full responsibility for the contents below, and believe that they represent a reasonable and accurate summary of the major recommendations and the views of most participants. More complete details are provided in the working group reports.

Preservation and Reorientation of FSU S&T Is in the U.S. Interest

Scientists and engineers in the FSU will play a key role in the economic revitalization necessary for a successful transition to open and stable market-driven democratic societies, which is in the economic and security interests of the U.S. New scientific and technological challenges in civilian areas for FSU specialists can help divert technical talent away from military pursuits. Achieving U.S. goals of shrinking and redirecting the FSU military R&D effort and developing the S&T component of the civilian economy will require providing new opportunities for both FSU weapon scientists and non-weapon scientists, especially in collaborations with American scientists. These opportunities for collaborative efforts will also allow FSU specialists to help expand frontiers of knowledge in areas of direct interest to the American scientific community and to U.S. business.

Time Is of the Essence

Without opportunities and financial support to address technical challenges, FSU S&T human capabilities are being rapidly eroded through an external and internal "brain drain." Of special concern, temptations are increasing for FSU military scientists to look abroad for opportunities to use their capabilities. Many of the best S&T facilities which are standing idle may soon atrophy. The window of opportunity for U.S. commercial interests to draw on FSU S&T achievements may close as other countries select the best commercial targets. The new FSU leadership will soon be making critical decisions in areas such as research priorities, intellectual property rights, and education accreditation and related policies; and there are one-time opportunities to influence these decisions. The U.S. can play a leadership role among western countries in revitalizing FSU science and technology if we act quickly. Cooperative projects with U.S. scientists and engineers will encourage FSU specialists to remain in place and to help in building a civilian market-oriented economy.

Summary of Key Recommendations

1. The national security, economic, and scientific interests of the U.S. can significantly benefit by expanded cooperative programs in the next several years that provide new research opportunities for critical FSU weapon scientists and the best FSU non-weapon scientists. The existing $400 million that Congress appropriated pursuant to the Nunn-Lugar Act (the Soviet Nuclear Threat Reduction Act of 1991) within the Department of Defense (DOD) budget is an appropriate source for funding many of these programs this year.

2. Criteria for funding through the new International Science and Technology Center proposed by Secretary Baker and Foreign Minister Genscher should include a broad definition of "weapon scientists and engineers," including relevant specialists at academic and research institutes who have worked on Soviet military R&D efforts. Special attention must, of course, be given to those specialists with critical weapons knowledge and skills. Center-supported proposals that are collaborations of FSU weapon scientists, FSU non-weapon scientists, and U.S. researchers would be the most effective means for achieving U.S. goals of shrinking and redirecting FSU weapon R&D programs and in increasing the transparency of FSU weapon laboratories.

3. In addition to the funds available in this and future fiscal years for key FSU weapons scientists and engineers through the new Center, funding at least on the same order of magnitude should be made available for programs outside the Center for FSU non-weapon scientists and engineers. Thus, at least $25 million for weapon scientists through the Center and $25 million for non-weapon scientists through other programs are needed in this fiscal year; even more would be appropriate considering the urgency of the

situation and available opportunities. Expanded funding should be made available in future years as justified through reviews of the programs. Awards should be based on scientific merit and potential contributions to U.S. objectives.

4. The extramural research programs of the National Science Foundation (NSF), the National Institutes of Health (NIH), the Department of Energy (DOE), and the Office of Naval Research (ONR) offer the important opportunity of scientist-to-scientist collaborations, which can be implemented rapidly. U.S. researchers know the best specialists in the FSU in their fields who would make excellent research partners. Funds should be allocated to these agencies (from the $25 million for non-weapon scientists) for use by their grantees for the purpose of direct scientist-to-scientist collaboration. U.S. researchers could provide travel funds, short term stipends, reagents, and spare parts from their supplemented grants. Joint publications would result from these activities.

5. A portion of the new funding for non-weapon scientists should also be made immediately available through the nine existing intergovernmental agreements that support civilian research and development (R&D) between the U.S. and FSU. This new funding would be added to existing cooperative programs of the NSF, NIH, DOE, USGS, EPA, NRC, NASA, and other federal agencies. This is an effective mechanism for near-term impact in terms of improving collaboration with competent scientists in the FSU on projects of interest to the U.S.

6. Existing procurement regulations and other administrative guidelines inhibiting research contracts from U.S. agencies to research units in the FSU should be reviewed and minimized. The recent contracts negotiated by DOE with FSU research institutes in fusion research and high energy experimental physics provide useful guidance.

7. The President's proposal for assistance to the FSU in agriculture, health, and energy should be strongly endorsed. The U.S. government should examine the science and technology (S&T) needs and opportunities, including R&D needs, associated with these assistance efforts.

8. The U.S. government should promptly modify the apparent restrictive policy concerning acquisition of advanced technologies and technical expertise from the FSU by American firms, including those with large DOD contracts. Reducing U.S. governmental impediments to appropriate activities of the U.S. private sector in the FSU can have immediate impact in terms of increasing collaboration with FSU scientists and engineers, reducing the FSU military industrial complex by redirecting many of its scientists and engineers to civilian projects, and promoting improvements in the economies of the FSU republics. The U.S. government should continue its related efforts to reduce unnecessary export controls,

particularly in the fields of computers and telecommunications, in close consultation and coordination with its CoCom partners.

9. Additional funding from anticipated foreign aid programs and the $400 million could be effectively used to facilitate conversion of FSU non-nuclear military technologies to civilian applications through such mechanisms as providing venture capital for U.S.-FSU projects, supporting feasibility studies by U.S. firms interested in investing in conversion projects, and providing technical assistance to FSU firms that are assessing marketing and technical opportunities for reorienting military technology to civilian applications.

10. As part of the U.S. economic assistance program to the FSU, the U.S. government should consider high technology R&D as a target for investment support. Such an effort would build on the emerging entrepreneurial abilities of FSU scientists and engineers while stimulating high value-added commercial activity.

11. The U.S. should strongly encourage FSU authorities to promptly enact legislation concerning real property ownership rights and intellectual property rights; to eliminate tax on foreign currency coming into FSU to support S&T; and to continue on the path to ruble convertibility and privatization.

12. A special fund of $50 million to $100 million should be established to help replenish and refurbish equipment, journals, and books used in FSU laboratories of special importance. The U.S. should take the lead in obtaining the necessary funds from bilateral and multilateral assistance agencies.

13. The U.S. representatives to international organizations (e.g., World Bank, UNIDO, FAO, WHO, UNDP, OECD, NATO) should urge greater support through these organizations for FSU S&T.

14. American and FSU specialists should undertake evaluations of FSU capabilities in selected areas of science and engineering of particular U.S. interest to assist in targeting cooperative activities and in utilizing the capabilities of unique FSU facilities and data banks of special importance.

15. Significantly expanded cooperation in environmental R&D would support U.S. goals of sustainable growth in the FSU and would enhance international efforts to understand global change.

Past U.S. Efforts Provide a Point of Departure for Expanded Programs

Many intergovernmental S&T agreements are hindered due to uncertainties regarding FSU collaborators. Air fares for FSU participation inhibit business as usual, and some important aspects

of S&T are not being addressed. Nevertheless, some of these agreements, as well as the extramural programs of some agencies, provide mechanisms for identifying and funding programs of great importance, and the partnerships within the FSU can be sorted out very quickly. For example, the programs of NSF, NIH, DOE, and ONR are well-suited to respond to the needs of basic research of interest to U.S. scientists, while programs of mission agencies such as EPA, DOE, USGS, and NASA provide mechanisms for Americans to gain access in a highly cost-effective way to important FSU specialists and facilities of direct interest to the programs of these agencies.

U.S. businesses are prepared to take advantage of many technical opportunities in the FSU, but many hesitate due to uncertainties regarding U.S. policies on technology transfer as well as inadequacies in the legal/economic framework within the FSU. Meanwhile, competitors from Germany and other countries receive stronger financial incentives from their governments and are gradually establishing business alliances with many of the most promising organizations in the FSU.

The new Center for support of FSU nuclear weapons scientists should offer many opportunities for FSU specialists to redirect their activities to civilian purposes and thereby shrink the size of the FSU military R&D effort. It also provides a base for rapidly expanding cooperative programs in other areas of science and technology.

Many FSU S&T activities are linked to programs of international organizations in which the U.S. plays an influential role (e.g., World Bank, UNIDO, FAO, WHO, NATO, OECD), and these organizations are in a position to direct additional resources to the FSU with encouragement from the U.S.

Several major U.S. private foundations are interested in helping to preserve the science and technology community in the FSU, and they can launch new programs very quickly. Their resources are limited, but they should be encouraged and complimented for their efforts to select special niches for their support (e.g., providing journals and electronic mail equipment).

American scientific professional societies are also rising to the challenge and creating innovative programs to assist their colleagues in the FSU. The American Astronomical Society has raised funds from its members to provide small research grants to FSU astronomers. The American Association for the Advancement of Science, with support from the MacArthur Foundation, will be providing help in maintaining journal subscriptions. Individual American scientists are seeking mechanisms for donating their journals and used equipment to FSU colleagues.

The National Academy of Sciences, National Academy of

Engineering, and Institute of Medicine are examining ways in which they can contribute to the revitalization of FSU scientific and engineering capabilities. The National Academy of Sciences has already changed its long-standing cooperative program to ensure that FSU participants are selected on the basis of evaluations by their American colleagues. In addition, consideration is being given to: undertaking evaluations together with FSU colleagues of FSU capabilities in important fields of science and technology (including those of potential commercial importance such as materials), sponsoring workshops for FSU and American researchers to develop collaborative research agendas and proposals in selected subfields, and working with counterpart organizations in Europe to improve coordination of western initiatives. The American Academy of Arts and Sciences is also pursuing, through a recently-created special committee, ways in which it might help the FSU communities in the sciences, social sciences, and humanities.

Special Considerations for New Programs

Programs supported by the United States should be based on mutual benefit and should not simply be responses to the economic plight of FSU specialists and institutions. Programs should be a mix of: (a) collaborative projects developed jointly by FSU and U.S. researchers and/or teams of researchers with the projects selected competitively on the basis of merit and (b) targeted projects designed to preserve and utilize the capabilities of unique FSU facilities and data banks of special importance to U.S. science and technology interests. Coordination of bilateral approaches with activities of other countries and international organizations is important and synergistic, but should not slow down the U.S. response. Whenever possible, implementation should begin within the next several months. Programs should be subject to careful review after the first year, with attention both to technical payoff and financial accountability. If benefits of these programs to the U.S. are as high as we believe they will be, the programs should be supported with increased funding over the next several years.

Other Promising Approaches that Deserve Careful Study

The proposal of Representative George Brown to establish a binational science foundation between the FSU republics and the U.S. is a welcome initiative with the possibility for long-term mutual benefit. The Brown proposal deserves careful study by the U.S. government. The policies and activities of the Export Import Bank, OPIC, and the Trade and Development Program might offer greater incentives for American investments in the FSU. Expanded authorities of U.S. agencies to enter into contracts with FSU organizations, when such arrangements are particularly beneficial to the missions of the agencies, can be very important; and the administrative details need to be carefully worked out.

In conclusion, we appreciate very much your soliciting the advice of the U.S. science and engineering community on these important issues. We hope that the recommendations and comments in this letter and in the four working group reports will be helpful to you in developing U.S. initiatives to respond to challenges and opportunities provided by developments within the FSU S&T community.

We would like to thank for their efforts in leading three of the working groups: Dr. James Wyngaarden, Foreign Secretary of the National Academy of Sciences and Institute of Medicine (Basic Research Working Group); Dr. Gerald Dinneen, Foreign Secretary, National Academy of Engineering (Commercialization of Technology Working Group); and Dr. Alvin Trivelpiece, Director, Oak Ridge National Laboratory (Interdisciplinary Problem-Oriented Research Working Group). We would also like to thank for their help in organizing the meeting and preparing this report the Office of International Affairs of the National Research Council (Dr. William Colglazier, Executive Director; Mr. Glenn Schweitzer, Director, Office for Central Europe and Eurasia; Dr. Gary Waxmonsky, Associate Director, Office for Central Europe and Eurasia; and Peter MacDonald and Kathleen Trivers of their staff.) We are especially grateful to Dr. David Hamburg and the Carnegie Corporation which, along with the National Research Council, provided financial support for the meeting.

We believe that it is in U.S. interest to act immediately and aggressively. If we or the National Research Council can provide you with any further assistance, we would be pleased to do so.

Sincerely,

Dr. Guyford Stever
Commissioner
Carnegie Commission
on Science, Technology
and Government

Dr. Frank Press
President
National Academy
of Sciences

Dr. Ashton Carter
Director
Center for Science
and International
Affairs

REPORTS OF WORKING GROUPS

AND

PARTICIPANT LIST

Working Group on Weapons Scientists and Engineers

The working group addressed the US interest in programs of assistance and cooperation with weapons scientists and engineers (S&Es) in the FSU and considered how such programs might be structured for maximum effect. While the working group foresees and supports sustained programs of assistance and cooperation extending over years, the group's deliberations focused on first steps that could be taken immediately and urgently. The working group took particular note of the applicability of the Soviet Nuclear Threat Reduction Act of 1991 (the so-called Nunn-Lugar Act) to the support of such a program in this fiscal year.

The group encourages a broad view of military-related work, urging that it not be confined to nuclear weapons but encompass all military-related technical work in the FSU. Moreover, since one of the objectives of the programs of assistance and cooperation is to foster the reorientation of weapons scientists and engineers to peaceful civil work, programs should not be confined to weapons scientists only, but should extend to other types of projects covered by other working groups in this meeting.

Objectives

The working group noted that the objectives of the programs of assistance and cooperation discussed and the interests of the United States in such programs are broad and diverse. They are not completely encompassed by the familiar stereotype that involves somehow preventing an FSU "weapons scientist" from emigrating to a country that is the target of US nonproliferation policy, though that is surely an objective. The full range of US objectives includes:

1. To promote the shrinkage and reorientation to productive, peaceful purposes of weapons-related activities carried out in laboratories, institutes, and state enterprises of the FSU;

2. To stabilize the situation of weapons scientists and to anchor them in peaceful projects designed to benefit their own homeland so they are not tempted or forced to seek employment or military markets outside the FSU and thus to contribute to proliferation;

3. To assist the transition to democratic institutions and a market economy in the FSU by encouraging its S&E communities to conduct basic and applied research aimed at addressing pressing social needs and economic development;

4. To promote access and transparency in the hitherto closed weapons complex of the FSU;

5. To promote joint research of mutual benefit between S&Es in the FSU and American or other western partners; and

6. To demonstrate the respect of the American people and the international scientific community for the considerable technical capabilities of FSU S&Es.

General Characteristics of Needed Programs of Assistance and Cooperation

The programs should support projects that satisfy the above objectives and also the following criteria:

1. The projects are technically sound.

2. The results of research will address pressing social and economic needs of the FSU and/or are of mutual benefit to the FSU and the United States.

3. The proposing entities can demonstrate their ability to accomplish the work.

In terms of technical content, the working group judged that useful projects of technical assistance and cooperation could probably be devised in the areas of:

-- secure and environmentally safe interim storage and eventual elimination of nuclear weapons and other weapons of mass destruction;

-- storage and disposal of special nuclear materials;

-- nuclear safety, including biological effects of low-level ionizing radiation;

-- environmental monitoring and cleanup, including cleanup of military-related facilities;

-- civil energy, transportation, and telecommunications;

-- fundamental research and associated instrumentation in such fields as high-energy physics, nuclear physics, fusion, plasma physics, geophysics, and computer science; and

-- social systems science, technology assessment, and public policy (similar to the types of studies conducted by the US Office of Technology Assessment or the International Institute for Applied Systems Analysis that are focused on the relationship of science and technology to society).

The working group believes that useful assistance and cooperation projects can take many forms and that it would be premature at this time to focus them on a single model type. Useful projects might involve collaboration of FSU weapons laboratories/institutes/enterprises with selected US Government

laboratories, industry, or universities; three-fold collaboration among FSU weapons and non-weapons establishments and US partners; and projects undertaken individually by FSU weapons establishments and monitored by US entities. (The group recommends that when there is no US partner in a project, a US monitor be named to certify that the work proposed is being accomplished.) Likewise, projects might be proposed by FSU laboratories or other institutions or proposed by individual scientists or groups, provided that they can demonstrate an ability to carry out work.

While both individuals/small groups and institutions in the FSU should be encouraged to develop proposals (and some groups might want to separate themselves from their institutions and establish new civil/commercial entities), maximum effect will be achieved if weapons-related institutions are engaged as institutions in some programs, and if cooperative programs contribute to reorienting their programs and infrastructures away from military work to peaceful purposes. Thus, unlike other types of assistance and cooperation discussed by the other working groups, collaboration with FSU weapons communities requires emphasis on involvement of institutions (and their accompanying infrastructures) in addition to individual investigators. There are good reasons for this difference: first, emigration abroad of engineers and technicians from the FSU weapons establishment is no less serious than the emigration of key scientists; second, the infrastructures of the weapons laboratories are very well developed (generally better than those of the civilian sector); third, in many cases the shrinkage of the FSU weapons program will be promoted better by involving entire institutions (key scientists and infrastructures) in non-military activities. Identification of joint, multilateral, or FSU-only projects worthy of support should take account of these special circumstances. The working group believes that there are indeed worthy projects that take this form.

However, the working group is aware of the necessity to embolden investigators to act independently of existing bureaucracy and management. Thus, US-supported programs should also emphasize projects proposed by individual investigators and by new civil/commercial enterprises spun off from military enterprises, and such projects with spinoffs should be encouraged in addition to institutional projects.

Starting the Process: Catalytic Efforts

The working group recognized the very fluid situation in the FSU, the historic isolation of FSU weapons-related scientists, and the fact that western scientists are just beginning to explore the scientific strengths and weaknesses of the former Soviet system. Thus early attention must be given to the processes of expanding access to the FSU weapons establishment, promoting contact between potential collaborators, and developing project proposals.

These catalytic efforts could begin immediately and could include grants to support problem-focused workshops, joint conferences, and site visits; conceptual design of projects, test beds, and pilot projects; and electronic mail and other elements of telecommunications infrastructure (e.g., direct links via satellite dishes located at key collaborating facilities in the FSU). The working group recommends that such activities begin immediately. They should not await determination of the overall future scope of the program, and indeed they are a necessary prerequisite to such a program.

The working group did not attempt to estimate the dollar volume of useful projects that would likely develop in such a program but believes the program should not be confined to the $25 million under discussion in connection with the Center (see below).

The Moscow Center

The United States, Russia, and Germany (through the EC) have agreed to establish an International Center for Science and Technology in the Moscow area to serve as a "clearinghouse" for research projects involving entities in the FSU that have special weapons expertise. Discussion of the ground rules and modus operandi of the Center is just beginning. The working group was generally impressed with the preliminary US plans for the Center and urges prompt commitment of at least $25 million of Nunn-Lugar funds to the Center and prompt establishment of the Center. The working group makes the following additional observations.

The Center seems to be an appropriate vehicle for the "catalyzing effort" described above, and could become an institutional mechanism for the program of sustained assistance and cooperation with FSU weapons entities in future years. The Center's location in the FSU is important, given the need to gain on-the-ground acquaintance with the weapons enterprises and scientific communities of the FSU. The working group urges attention to republics in addition to Russia, which also have considerable military industries. The Center also can serve as "matchmaker" between scientists and appropriate projects and funders. Finally, the Center promises to engage the resources of European and possibly Japanese participants, which the working group regards as highly desirable. However, the working group believes that the Center should not be the sole or exclusive vehicle for such cooperation.

Present plans call for the Center to act on proposals in two steps. In the initial step, projects will be vetted for appropriateness and merit by the Center staff and board. In the second step, funders (governments and private parties) will choose projects for support on a case-by-case basis. The Center itself will have no power to make funding commitments apart from the national representatives on its board. The working group is

concerned that unless some funds are committed to the Center from the beginning, the Center will be seen as a needless and powerless middleman between proposers and funders rather than as a clearinghouse. More importantly, the establishment of the Center will not reflect the commitment and seriousness of purpose of its founding governments. The working group therefore recommends creation of a Director's Fund of committed funds, comprising perhaps one quarter of Center funding, to be obligated by the Center itself.

Finally, the working group noted that in order for projects to fulfill the objectives outlined above, involved scientists will need to make multi-year commitments to them. This commitment in turn calls for Center funding that extends beyond this year's Nunn-Lugar appropriation. The United States therefore needs to ensure continuing funding commitments to the Center. Additionally, the Center should be capable of making multi-year commitments.

Potential Role of Existing Bilateral Agreements

Several of the nine existing science and technology agreements also provide a mechanism for engaging FSU weapons S&Es in collaborative activities. For example, the agreements administered by DOE/NRC, NSF, and EPA could involve participation of FSU specialists who previously were not given the opportunity to collaborate in areas of obvious importance to these agencies.

Additional Steps in the United States

The working group believes that collaborative projects involving FSU weapons activities and western partners (public or private) will emerge spontaneously if veils of secrecy are lifted in the FSU. Projects of mutual advantage might even be supported through barter agreements between the collaborating parties. But substantial bureaucratic and legal barriers exist to such spontaneous collaboration in the United States, and the working group recommends that a complete review of such barriers be undertaken urgently to remove all those that derive from the cold war period and no longer serve US interests.

The working group also notes that legal counsel in different agencies is interpreting the Nunn-Lugar legislation in different ways and in a manner that seems excessively cautious and strict, especially regarding the so-called certifications. Government-wide consensus on these interpretations should be reached soon, so that they do not remain a barrier to action.

Additional Steps in the FSU

The working group believes that for the proposed types of programs to succeed, the Russian government (and, where applicable, other governments of the FSU) must take the following steps, which

are preconditions to success:

1. Participating weapons facilities need to open up to outside visitors and collaborators, limiting restricted security areas to the maximum extent possible ("higher fences around smaller areas").

2. Weapons laboratories must relax controls over individual scientists and engineers so they can communicate directly with western collaborators.

3. Participating FSU weapons facilities need to allow establishment of electronic communications with the outside.

4. Participating weapons facilities need to make laboratories, instrumentation, and other infrastructure available for non-weapons work. Access to that infrastructure will often be the principal attraction for western collaborators.

5. FSU governments need to establish appropriate tax treatment for foreign currency funds provided to institutions as part of this program.

Working Group on Basic Research

The working group on Basic Research proceeded from the position that it is in the economic and national security interests of the United States to preserve the strong scientific and technical capability of the Former Soviet Union (FSU) in order to sustain the transition to an open society and a market-oriented economy.

The FSU is in crisis. Dramatic changes in the region, although undoubtedly positive in a political sense, leave scientists in a precarious niche since there is very limited money for science. Salaries for scientists within and outside the academy structure are pitifully low, and FSU scientists are becoming increasingly isolated from their international colleagues owing to the virtual absence of hard currency necessary for western journals and for travel to meetings outside the FSU. Outstanding research groups are disintegrating, and some of the best scientists of all ages are leaving for temporary, and in some cases permanent, positions abroad. If the exodus of FSU scientists continues, and if FSU science and technology wither and flounder, it is difficult to see how the FSU nations can prosper. Science and technology, together with capital and free social institutions, propel a modern economy.

This situation is clearly a security issue for the United States. The United States has already invested huge resources in the "containment" of communism, and a comparatively small investment now could be very effective in stabilizing the FSU scientific establishment. This investment may also encourage scientists who have left for temporary positions to return to assist in the stabilization process. In our view, international disaster could ensue if the present political and economic restructuring of the FSU were to fail and new totalitarian regimes were to reemerge. An enlightened program that would help to stabilize FSU science and technology would make an important, perhaps decisive, contribution to the future of these burgeoning democracies.

Even though many prominent scientists have left the FSU, large numbers remain. The major scientific resources are to a large extent still intact and now free from bureaucratic strangleholds. They are free from undesirable interference, free to enter into collaborative agreements, and free to accept financial support open to accounting supervision. The cost of operation in the FSU (salary, maintenance, etc., but excluding equipment) is much less than the cost of comparable activities in the West. Moreover, the FSU possesses unique assets such as research ships, astronomy installations, botanical collections, and historic libraries, as well as world-class research groups.

The working group recommends that the United States undertake a number of initiatives that will help to stabilize science and technology in the FSU. We have based these recommendations on the concept of mutually advantageous binational collaboration. There are many competent and well known FSU scientists and high-quality research groups with whom American scientists could form collaborative research and technical projects. Such projects should not be viewed primarily as assistance programs; the working group is not proposing a welfare system for FSU scientists. We are proposing an expansion of international collaborative efforts, the results of which could be of substantial value to the American people and the American economy. There are, in fact, critically important projects to which both partners can make significant, complementary contributions.

The working group recommends identification of high-quality individuals and groups with whom to collaborate directly. Although many such are known to the American scientific community, the working group recommends that small teams of American scientists visit the FSU to assess first hand the current situation in institutes and university departments. Decisions regarding feasibility of productive collaborations should be based upon the judgment of such teams. These visits would also help to identify emerging younger researchers who could participate in collaborative activities, but may not yet be well known to American scientists.

The working group recommends that US contributions to collaborative research be principally in the form of supplies, such as equipment, journal subscriptions, travel funds, and communication systems (for example, e-mail), rather than direct transfer of currency or salary support (except during brief fellowships outside the FSU). Furthermore, the working group recommends that any form of assistance be provided directly to the individual scientists and groups, rather than to institute administrators or academy officials for distribution. Whenever possible, cooperation between scientific institutes and educational institutions in the FSU should be encouraged.

Decisions regarding potentially advantageous collaborations should be based upon principles of merit review now thoroughly familiar to US scientists. However, in recognition of the newness of such concepts to FSU scientists, merit review should give predominant weight to track records rather than to "grantsmanship." In addition, the application process should be kept relatively simple (short applications) and the review process should be expedited.

The discussion focused on an emergency, short-term approach to stabilizing science in the FSU and establishing collaborative projects between FSU and American scientists. The situation is urgent, and we believe that measures should be taken during this fiscal year. American support of selected FSU individual

scientists and research groups that qualify for extensions of peer-reviewed US research projects could be highly beneficial to both countries and would send a message of hope to FSU scientists far beyond the quantitative scope of initial efforts.

Clearly, American efforts to preserve science should not focus exclusively upon redirection of scientists who have participated in the creation and production of weapons of mass destruction. It is equally important that the United States pay close attention to scientists in the basic physical, chemical, geological, biological and mathematical sciences.

Recommendations for the US Government

Within the next six months

1. Immediately allocate between $5,000,000 and $10,000,000 of additional funds for supplements to existing American grantees of agencies such as, but not limited to, NIH, NSF, DOE, and ONR. Such supplements might come from the $400,000,000 authorized by the Nunn-Lugar Act through interagency transfer to the research agencies or from other sources if more appropriate. These supplements will allow the grantees to initiate or expand collaborative activities with FSU scientists and rapidly provide some assistance. By using the best features of the NIH and NSF mechanisms to support the collaboration of American scientists with FSU scientists, immediate amplification of funds may allow these models to be expanded many-fold in the current fiscal year. Such an effort would represent a significant response to the present emergency and send much needed encouragement to beleaguered FSU scientists who are a main resource in rebuilding the societies and economies of the FSU. In addition, such efforts would substantially expand research projects of benefit to the American people.

2. Immediately develop an administrative mechanism for transfer to FSU scientists of equipment from US laboratories that has been displaced by more recent acquisitions and that remains capable of producing valuable research results. Such equipment should only be transferred to FSU scientists who qualify for collaborative projects with US scientists and who can effectively use the equipment in the approved collaborative research, thus ensuring that the US investment will further benefit domestic research objectives.

3. Facilitate the issuance of multiple-entry US visas for non-weapons scientists and engineers, such as are now offered to members of the business community, unless there are overriding concerns over potential violations of export controls. The Department of State should give special consideration to FSU scientists returning home for short

visits to assist in the improvement of working conditions in the FSU.

The near term

1. Support Congressman George Brown's proposal for a binational foundation, with the modification that the foundation be in the form of a withering endowment of 10 years. At the end of this period, both sides should evaluate the state of FSU science to determine if the continuation of this type of support for research cooperation is necessary and mutually beneficial. In order for a binational science foundation to have significant impact, it should be capitalized at a minimum of $200,000,000, with both interest and approximately 10 per cent of principal available for support of peer reviewed research projects each year. Many of the experiences and lessons of the US-Israel Binational Science Foundation (as well as experiences of the Binational Agricultural Research and Development Foundation and Binational Industrial Research and Development Foundation) can serve as general guidelines for the establishment and management of the proposed US-FSU foundation.

2. Initial assistance should be offered in the form of laboratory equipment, development of improved means of communication, and travel, but not in the form of salary assistance. When a banking system with appropriate accountability is in place, the United States should not rule out efforts to transfer foreign currency directly to FSU scientists for support of research programs.

3. Encourage efforts of non-governmental organizations that are seeking ways to assist FSU scientists by supporting their research.

The long term

1. Cooperate and coordinate with activities initiated by other governments, scientific societies, the European Community, the World Bank, and international organizations involved in science and technology.

2. Sponsor programs on the management of science for FSU research administrators and scientists. Such programs should include an introduction to peer review procedures and grant management for many colleagues throughout the FSU.

Recommendations for FSU Governments

Within the next six months

1. Encourage FSU scientists now working in the West to return

to the FSU to work with other scientists, and assure freedom to travel back to their jobs outside the FSU. The offer of a leave of absence is in the best interest of the home institution, and job security should be assured even beyond the one-year period of absence currently recognized by the Russian Academy of Sciences, at least for a portion of established FSU scientists.

2. Guarantee continued salary support to FSU scientists involved in collaboration with American scientists throughout the period of the collaboration.

3. Provide internal travel support to FSU scientists.

4. Provide tax exemptions for hard-currency grants.

5. Facilitate the issuance of multiple-exit documentation for FSU citizens working in the West who wish to return for frequent visits to assist their home institutions and/or scientific colleagues.

The near term

1. Assist in identifying promising young researchers who are not yet known to American scientists (i.e. in basic sciences such as genetics that are essential for advances in agriculture and medicine).

2. Establish a clearing house or secretariat that can assist FSU scientists to make contact with organizations, programs, and scientists in the United States and other countries.

The long term

1. Implement promised reforms as quickly as possible, including the reform of tax laws, intellectual property rights, and education.

2. Encourage academies, universities, and industries to establish cooperative linkages and to bridge the non-interactive traditions of the previous regime.

Recommendations for Non-Governmental Organizations

The near term

1. Scientific societies (national and international) should be encouraged to ask members to assist FSU scientists by sending journals, expanding electronic mail networks (especially outside Moscow), and providing funds for travel to meetings.

2. NGOs can help to identify individual scientists and research groups that are leaders in their fields with whom collaborative research could be established.

3. Private foundations and professional societies can help to publicize opportunities for collaboration of FSU scientists with American scientists.

4. Private organizations should establish mechanisms for the transfer of hard currency to the FSU, when accountable banking systems have been established.

The long term

1. NGOs and scientific societies are encouraged to identify and support similar organizations in the FSU and to promote their growth.

Recommendations for NAS/NAE/IOM

The NAS had more than 30 years of experience in cooperating with the Academy of Sciences of the USSR. The Academy complex should build upon this experience of cooperation with FSU institutes and scientists in the following ways:

The near term

1. Make recommendations to the US and FSU governments on new approaches to technical assistance based on experiences with the Support for East European Democracy Act.

2. Send small exploratory groups to the FSU in as many different fields as possible to assess the quality and viability of small research groups and the opportunities for productive collaboration.

3. Take an increasingly active role in counseling prospective American collaborators on available opportunities and programs.

The long term:

1. Establish a bilateral advisory committee to assist the FSU and US Governments to implement new programs of cooperation. The committee would include FSU scientists who know western science well. The FSU members of the committee should extend beyond the established academies of sciences in the FSU and should be supported by the FSU governments. Among its activities, it could assist in defining a framework for intellectual property rights.

2. Serve as a catalyst for assembling national and international experts to participate in peer/merit review of proposals of FSU scientists. Provide guidelines similar to those established and tested over time by NSF, NIH, and other US funding agencies.

Working Group on Commercialization of Technology

The working group included senior executives from companies with strong business interests in the FSU, specialists with experience in transferring FSU technologies to American firms, economists specializing in FSU developments, representatives of US federal agencies with strong engineering interests, and representatives of engineering societies.

There should be considerable opportunities for establishing commercially viable enterprises in the FSU. The FSU has developed many good technologies, particularly in military enterprises (e.g. opportunities for application of BW capabilities to vaccine production and for new applications of aerospace technologies). Many young FSU scientists and engineers have exhibited considerable grass roots entrepreneurship, although on occasion some of their enthusiasm may be misdirected. Also, there is widespread interest in the FSU in working with American businesses and learning western approaches to a market economy.

However, the paradox is that relatively few commercial arrangements have been made between American and FSU organizations. Companies of other countries seem to be more successful, particularly firms from Germany and recently Korea and Japan. This limited American involvement is particularly significant since the window of opportunity for joint ventures and other types of business alliances may be closing either because firms of other countries simply usurp the most attractive joint venture opportunities or existing FSU capabilities erode to the point that they are no longer interesting.

There are few generalized conclusions and recommendations that apply to all industrial sectors and all types of organizations. For example, large firms have specialized staffs for identifying business opportunities in the FSU whereas small companies cannot afford such specialization. Firms involved in development of hardware have different concerns than software firms. Also, service companies use different criteria than manufacturing companies when considering investment commitments. Nonetheless, a few desirable actions that are applicable on a broad basis and would be beneficial to both American and FSU interests can be identified.

Much of the discussion centered on foreign investment, but the importance of FSU efforts to commercialize their own technologies for the internal market was also highlighted. While many technologies developed with or without foreign partners can potentially serve both the internal and global markets, there are special considerations for FSU firms attempting internal commercialization without access to the expertise of foreign partners.

Throughout the discussions, the complexities of understanding

the many factors that affect business decisions or should affect decisions within the FSU were very apparent, and the need for more extended consideration of the likely impacts of any individual measure that is proposed was recognized. Adding to the complications are the uncertainties within the FSU military industrial complex associated with the process of conversion. Conversion affects not only individual firms and local areas but in some cases can have dramatic effects on large geographic regions where the defense industry has become the only source of possible employment for hundreds of thousands of workers.

Four suggestions for immediate consideration emerged from the discussions:

-- The FSU must clarify real property ownership rights as a first step toward any type of meaningful market economy.

-- If US firms are to become more seriously engaged in commercialization of FSU technologies, and especially technologies that have been developed within the military sector, the US government must clarify its policy, and particularly the policy of DOD, toward acquisition by US firms of high technology from the FSU.

-- A portion of the $400 already earmarked for dismantling of the FSU weapons complex (e.g. $25 million in addition to the $25 million allocated for reorienting the activities of the nuclear weapons scientists) should be made available to facilitate conversion of FSU non-nuclear military technologies to civilian applications through such mechanisms as providing venture capital for US-FSU projects, supporting feasibility studies by US firms interested in investing in conversion projects, and providing technical assistance to FSU firms that are assessing marketing and technical opportunities for reorienting military technology to civilian applications.

-- The US government should review its policies for sharing risks and financial burdens with American firms interested in investing in the FSU in the near term, including the policies, programs, and financial capabilities of ExIm Bank, OPIC, and the Trade and Development Program.

These and other suggestions for near-term actions by FSU and American institutions are set forth below.

Suggestions to Governmental Organizations of the FSU

The <u>Legal/Regulatory</u> Framework

1. Real property ownership rights need to be clarified as soon as possible.

2. The efforts that have been underway for many years to establish, implement, and enforce an appropriate legal framework for intellectual property rights should be revitalized.

3. Special steps are needed to ensure that regulatory agencies (e.g. organizations with responsibilities similar to those of FAA and FDA) do not become bottlenecks during the transition from Soviet to other institutions.

The Economic/Financial Framework

4. Establishment of a banking system that can serve as a reliable source of investment capital, including venture capital for innovation, and at the same time can help ensure the integrity of financial arrangements among FSU institutions and between FSU and foreign organizations deserves high priority.

5. Current efforts toward convertibility of the ruble should continue to receive strong emphasis.

6. Systems that encourage and reward economic competitiveness among firms should be strongly supported.

7. The current policy of heavy taxation on flows of foreign currency into the FSU should be modified.

Physical and Technical Infrastructure

8. Greater attention is needed at the national and local levels to providing access to electricity, heat, water, transportation, communication, waste disposal, and other services required for enterprises to operate on a competitive basis.

9. With the devolution of centralized responsibilities from the FSU to the independent states, special efforts are needed to ensure that there is no backsliding on the development and implementation of appropriate industrial standards which are consistent with international standards.

Attitudes and Approaches toward Science and Engineering

10. Scientific and engineering entrepreneurs, including key specialists spinning off from leading FSU research institutes, should be encouraged and not considered as an internal brain drain.

11. The size of many FSU research, development, and production organizations should be reduced to improve their economic competitiveness.

12. New systems of rewards are needed throughout the research establishment to foster projects that result in outputs which have clear relevance to economic needs of the FSU in addition to

resulting in publishable papers.

13. Greater attention to economics and management is needed in higher technical education institutions.

Suggestions for Agencies of the US Government

For NSC/OSTP/State/DOD/Commerce

1. US policy toward acquisition by American firms of high technologies from the former Soviet defense industry should be clarified, and American defense firms should be given a clear signal regarding those activities which are acceptable to DOD. This policy should be formulated on the basis of a careful evaluation of the many US interests that are involved, including the importance of high technology to a successful FSU transition to an open market economy, and the possibility that the current window of opportunity to acquire FSU technology may close as other countries increase their interest in FSU technologies.

2. A continuing relaxation of US export controls should be considered, particularly with regard to computer and telecommunication technologies.

For ExIm Bank, Overseas Private Investment Corporation, Trade and Development Program, AID

3. Consideration should be given to providing financial incentives through risk sharing and other approaches that will encourage American investment in the FSU. Among the approaches are support (through feasibility studies and guarantees) of local production of drugs and food processing equipment, possibly within the context of humanitarian assistance, export guarantees for investments in manufacturing equipment installed in the FSU, and encouragement of subcontracting of American firms with FSU institutions.

For Commerce/NSF

4. Cooperative research projects involving American industrial scientists spending time in the FSU and FSU scientists in the US should be encouraged.

5. Benchmark evaluations of selected subfields of FSU science and technology with potential for early commercialization should be carried out jointly between American and FSU specialists and institutions as a basis for targeting FSU internal financial support and American cooperative projects.

For State/Commerce

6. With the disappearance of services provided to foreign business by many agencies of the FSU, the US Government should strengthen

its supporting administrative infrastructure in the FSU to facilitate American business interests.

For State/NASA

7. A review of the opportunities for major collaborative space programs, including programs with commercial significance, should be undertaken before the FSU capability to participate disappears.

For AID/Commerce

8. Assistance in identifying opportunities for redirecting the enormous engineering capabilities of the military industrial complexes to commercially viable services and products, and particularly identification of marketability of services and products at home and abroad, is needed.

9. Assistance in the field of research management at the institute, laboratory, and enterprise levels is needed. This is in addition to the well recognized need for assistance in basic economics and cost accounting procedures in managing privatized enterprises. A major US initiative in this area could build on related US experiences in strengthening management capabilities in Central Europe, China, and other parts of the world.

Suggestions for US Industry

Becoming better informed of opportunities and impediments

1. Participation in trade fairs and exhibitions and in other activities organized by the FSU can open many doors in the FSU.

2. Special meetings devoted to developments in the FSU organized by trade and professional associations and other interested business organizations can help identify opportunities and problems.

3. Participation in consortia of business firms that establish offices in the FSU may be helpful to some companies.

4. Firms should take advantage of trade offices established in the US at the federal and state levels which follow developments in the FSU.

5. Business opportunities should be explored beyond Moscow -- throughout the Russian Federation and in other newly independent states as well.

Considerations for technology-based companies

6. Manufacturing and engineering staffs should explore possibilities for subcontracting in the FSU.

7. The experiences of companies which have established direct linkages among engineers and which have successfully defined subcontract tasks for component development should be reviewed by other companies with related interests.

Steps to improve the investment environment

8. Companies should bring problems and relevant experiences to the attention of the US Government with specific suggestions as to how to reduce legal, regulatory, financial, and other barriers to doing business in the FSU.

Suggestions for the NAS/NAE/IOM

1. The Academy Industry Program should consider organizing a meeting in Washington on commercialization of technology in the FSU.

2. The Academies should consider undertaking an evaluation together with FSU counterparts of FSU capabilities in one or two selected subfields of technology of potential commercial importance to the FSU (e.g. materials science).

3. The Academies should work with counterpart organizations in Europe to improve coordination of western initiatives related to commercialization of technology in the FSU.

Working Group on Interdisciplnary Problem-Oriented Research

The former Soviet Union (FSU) is undergoing a wrenching transition from a centrally planned to a market economy. In this process, it is imperative that the FSU successor states retain an ability to function in a complex technical world with the tools of a modern state. The FSU had a large and complex science enterprise that served its interests adequately. In the process of transition to a new economic structure, this enterprise is under serious threat of being dismantled in such a way that it may not recover. Without a suitable science and technology (S&T) base, the transition to a properly functioning, market economy will be difficult if not impossible. It is in the interests of the United States and of the entire international community that the S&T enterprise of the FSU be preserved and, as appropriate, reoriented, in such a way as to support the transition to a peaceful, modern, technology-based economy.

Part of the S&T enterprise of the FSU involves many areas of applied and interdisciplinary science and technology. These include management of biological diversity, preservation of the world's ocean resources, assessment of risks of earthquakes, stewardship of the Arctic regions, safe utilization of nuclear power, and the possible development of fusion power.

Collaboration between the United States and the FSU in many of these areas has a long history. For nearly twenty years, US mission agencies have collaborated with Soviet counterparts under a number of executive agreements. Known collectively as "S&T agreements," these instruments have facilitated bilateral collaboration in a number of areas including public health, environmental protection, space exploration, transportation, and energy. Activity under all such agreements was grounded in three principles, equality, reciprocity, and mutual benefit, and funded by each agency from its existing budget. An interagency working group on Soviet science and technology, known most recently as GOSSAT and chaired by the State Department, has sought to ensure coordination among the various programs and their conformity to US policy.

In general, the steps outlined below under the heading "Prompt Action" should be initiated by US Government entities. "Evaluations" and related activities, while they should include government specialists, should be organized by the non-governmental scientific community with financial support from agency supplements. "Events" such as workshops and colloquia could be undertaken by either governmental or non-governmental sponsors. "Longer Term Programs" will require greater involvement by the private sector, academic, corporate, and philanthropic, and will depend largely on the success of activities which have gone before.

Statement of Principles

1. It is in the interests of the United States to have a scientifically and technically strong FSU, so that when the former republics complete the transition to new political and economic structures, they have the capability to participate effectively in international scientific programs and also to establish modern science and technology-based commercial enterprises.

2. An important outcome of assistance should be maximization of mutually beneficial collaboration on important international problems of energy, the environment, public health, agriculture, and natural hazard mitigation.

3. The FSU is home to priceless scientific resources: collections, facilities, archives, data sets, and unique geographical sites.

4. Indigenous capacity to understand and manage environmental and energy processes and resources in the FSU is of interest to the international community.

5. Financial assistance should involve a mix of grants/contracts to individual researchers/small groups and core support for unique research facilities.

Steps FSU Authorities Should Take

1. Waive taxation on hard currency provided through contracts and grants and duty on all equipment and supplies provided in connection with collaborative research.

2. Facilitate open and unfettered access to research sites and data.

3. Inventory and make available appropriate former government/ party facilities as FSU contributions to bilateral/multilateral centers for interdisciplinary research, education, and training.

4. Seek PL-480-type arrangements for support for research collaboration if and when suitable resources become available.

Steps US Side Should Take

<u>Prompt Action</u>

1. To the extent possible, modify procurement regulations or other administrative guidelines inhibiting research contracts from US Government agencies to research units in the FSU. On the condition that FSU authorities act to ensure the integrity of USG research contract fund transfers, a US mission agency should be able to contract directly with FSU laboratories when the agency finds it cost-effective to do so from current accounts.

2. Existing cooperative S&T programs with the FSU should be augmented through supplements to participating US agencies via the NSC Working Group on FSU Soviet Science and Technology (GOSSAT).

3. Defray portions of FSU hard-currency costs associated with their participation in major international or bilateral research programs (e.g., ocean drilling, IIASA) in the current year.

4. Dispatch small team(s) to assess conditions affecting the most valuable FSU scientific collections, archives, facilities, data sets, and real-time networks. The most endangered of these would be targeted for priority attention via augmentation of existing agency programs (see above).

Evaluations

1. The US scientific community should both respond to requests from FSU authorities for evaluations of specific research sectors and initiate proposals to evaluate sectors, including those which best available information suggests are deficient (e.g., resource economics, epidemiology, multi-media ecological processes).

2. In advising on or carrying out research evaluations in the FSU, US participants should strive to enhance or create indigenous evaluation capabilities and more open, representative science policy processes.

3. In prioritizing among potential foci of research evaluation, an important consideration should be the goals and priorities of the larger US assistance effort.

4. In consultation with relevant technical agencies and the US scientific community, the Assistant Administrator for Research and Development within the Agency for International Development should undertake an assessment of the S&T needs and opportunities associated with the current US assistance effort vis-a-vis the FSU in the fields of health, food, and energy (e.g., technical infrastructure for maintaining standards of food and drug purity).

Events

1. Workshops on research management and grantsmanship to be held at various locations in the FSU.

2. Colloquia on ethical aspects of human/experimental subjects.

3. Specific problem-oriented symposia and conferences (e.g., Arctic methane emissions, die-back of marine mammal populations in Bering Sea) to be held in the United States or FSU.

4. Individual support for FSU researchers invited to participate

in activities outside the FSU concerning international scientific programs of major interest.

Longer-Term Programs

1. Young investigator exchanges on multidisciplinary problems (biodiversity, energy efficiency, coastal zone management, etc.).

2. Pilot-scale demonstrations of innovative low/non-waste or energy-saving technologies.

3. Establishment of interdisciplinary research and study centers within existing FSU facilities.

4. "Mentoring" or "sister laboratory" relationships between critical FSU research facilities undergoing restructuring or reorientation and US counterparts.

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